THE
ENGINEERING REVIEW.

Edited by
C. EDGAR ALLEN.

Vol. XIII. DECEMBER, 1905. No. 12.

THE MONTH.

LONDON TRAFFIC.—The main features of the proposals contained in the report of the Advisory Board of Engineers to the Royal Commission on London Traffic have already been set forth in the main report drawn up by the commissioners. As a standard work of reference on street locomotion, the last volume possesses much interest, and will doubtless prove most useful for the guidance of those upon whom devolves the work of improving the highways and of providing new traffic facilities. No one can seriously expect that the gigantic programme prepared by Sir John Wolfe Barry and his professional colleagues will be undertaken as a whole by any authority, or combination of authorities, representing the ratepayers of the metropolis. Moreover, it is by no means clear that the recommendations completely cover all existing difficulties. In addition to the vast constructional works contemplated, the report contains various suggestions that are more practicable because comparatively inexpensive. Among these proposals are some relating to the removal of tramway columns, lamp-posts, and cab-stands, in the middle of the streets, the more efficient regulation of omnibuses, and street improvements for relieving local congestion of traffic. If the municipal authorities would undertake these reforms, and Parliament would give a little more encouragement to tube railway and tramway schemes, matters would soon be improved to a very considerable extent.

IMPROVED TRAFFIC FACILITIES IN LONDON.— In spite of the fact that many schemes intended to add to the means of metropolitan communication have been held back during the sitting of the Traffic Commission, it is gratifying to look around upon the numerous improvement schemes that have been completed or are still in active progress. The opening of Kingsway is naturally the most striking of these, and when the underground tramway commences operation and has been connected with the southern system of the County Council the full value of this great work will be fully experienced. Unfortunately, Parliament have not been able to see the necessity of transpontine connection, thus showing how remarkably dense several hundreds of intelligent gentlemen can become when they lay their heads together. In spite of their enormous cost, the tramways of the County Council are doing a great work, and at the present time no fewer than seven new lines, covering about eight street miles, are being projected in addition to the electrification of the first section, about twenty-two miles, of the northern tramway system, an undertaking that will probably cost the ratepayers more than five millions. The same body also propose to spend £301,285 on street widenings during the year 1905-6. Further, it is

probable that powers will be obtained next session for the embankment tramway scheme, combined with the widening of Blackfriars Bridge or the building of a new bridge across the Thames. The inauguration and rapid extension of the tramway systems with which Sir J. Clifton Robinson is associated are other gratifying features, and almost equal activity has been shown by the Middlesex County Council and other bodies in tramway and light railway construction in the northern districts of Greater London. Next year we may hope to witness the opening of the Baker-street to Waterloo, and the Great Northern, Piccadilly and Brompton tubular railways. The Charing Cross, Euston and Hampstead line is also well under way, and will probably be completed early in the succeeding year. Apart from the foregoing enterprises, a noteworthy movement in the direction of more rapid locomotion is marked by the increasing introduction of motor omnibuses, wagons, and light vans, and it is probable that the Board of Trade will relax the rules which now unduly limit the speed of electric tramways in outlying suburbs. Thus things are really moving in London after all, if not so fast as could be desired.

Caisson Disease.—Various theories have been put forward to account for the physiological cause of the disease to which men are liable who work in caissons where compressed air is employed. The symptoms of the disorder include muscular pains, hæmorrhage from the nose and lungs, and partial paralysis, and it has been suggested that these effects may be due to muscular fatigue, imperfect ventilation, the presence of poisonous gases, congestion of the organs, and the bubbling of the blood owing to the liberation of nitrogen gas in the arteries. From experiments made in Newcastle during the construction of the pier foundations for the new high-level bridge, Professor Thomas Oliver, M.D., arrives at the conclusions that caisson disease is due to the liberation of gas in the blood owing to the too rapid relaxation of pressure in the air-lock, and that the safety of the workmen depends upon the allowance of ample time for the operation known as "decompression." The point is one deserving the careful attention of civil engineers and contractors who are compelled to employ compressed air in bridge building and other works.

Indian Railways.—Those of our readers who are interested in railway construction will find in a blue book, issued by the Government of India, full details relative to various projects which have been sanctioned and put in hand during the last fifteen months. Among these the most important is the Nagda-Muttra extension of the Bombay, Baroda, and Central India system, the total length being 343 miles and the estimated cost about £2,000,000. The construction of this line has long been advocated by the Bombay Chamber of Commerce in the interests of the port, and its completion will largely augment the carrying powers of existing railways in Southern India. Next in importance are the Gonda-Chandia and Panni-Nagpur branches of the Bengal-Nagpur system, with a collective length of 212·5 miles and an estimated cost of nearly £600,000. Work on the Ranaghat-Kathihar line, in Bengal, involves an expenditure of £700,000, a good deal of which will be devoted to bridge building. The Bengal and North-Western Railway and the Rohilkhand and Kumaon Railway have in hand several extensions representing a probable outlay of something like £350,000. In Northern India the chief works in hand are the Shahdara-Sangla loop of the North-Western Railway, 55 miles long, and a 27-mile extension of the Amritsar-Patti line. The remaining lines under construction are: an extension of the South Indian Railway from Mandapam to Rameswaram, 48 miles; the Akhawra-Bhairab-Bajar branch of the Assam-Bengal Railway, 19 miles; the Bhagalpur-Bauri branch of the East India Railway, 51 miles; extensions in the coal-fields on the Bengal-Nagpur system, 30 miles; the continuation of the Barsi Light Railway to Pandharpur and the construction of a second line to Tadwalla, 66 miles. Altogether, the railways under construction or sanctioned represent an addition of 3,138 miles to the existing total of 27,749 miles open for traffic. This is a useful instalment, although far too small for the rapidly-growing needs of the Indian Empire.

The Sanitary Protection of Water Supplies.—A useful contribution on the subject of sanitation with reference to public water supplies will be found in the current issue of *The Journal of the Franklin Institute*. Mr. Kenneth Allen, the author, is chief engineer of the water department at Atlantic City, N.J., and it is satisfactory to note that he emphasises the practical utility of chemical analysis. Without any desire to disparage the valuable work done by bacteriologists, we must point out that bacteriological examination has entirely failed to fulfil the anticipation of its

advocates. The organisms responsible for water-borne diseases are of particularly elusive character, and it is now generally admitted that the typhoid bacillus—the most important germ of the kind—cannot be detected in ordinary waters. On the other hand chemical analysis gives reliable data as to the present condition and past history of any water under consideration.

THE CUNARD TURBINE STEAMERS.—Much interest attaches to the two turbine steamers now in course of construction for the Cunard line. At the present moment, Germany owns the largest vessel afloat, although compensation is to be found in the fact that this magnificent specimen of shipbuilding was produced by a British firm. We refer to the *Amerika*, which has a length of 687 ft. and a beam of 74 ft. 6 in. The new Cunard liners measure 800 ft. long by 88 ft. beam by 60 ft. deep, or 90 ft. from the boat deck to the keel. Although 108 ft. longer, and 5 ft. wider than the *Great Eastern*, the engine power of these vessels is more remarkable than mere dimensions. When Brunel's masterpiece was launched she was seven times the size, and her engines had three times the power, of the largest Cunarder then afloat. The tables have long since been turned in this respect, and the motive power of each coming addition to the Cunard fleet will be 72,000 h.-p., or nine times that of the *Great Eastern*. Steam will be provided by Scotch boilers, with a collective capacity of 75,000 h.-p., and the mechanical part of the power plant is to consist of four 18,000 h.-p. turbine sets, which will be installed upon the same platform, to actuate a pair of propellers near the rudder and another pair in a more forward position. It is anticipated that the present speed record of 23·5 knots will be raised to fully 25 knots when the new vessels have been brought into service.

SMOKE ABATEMENT.—With the object of affording an opportunity for the discussion of the various ways in which the smoke nuisance may best be palliated, the Royal Sanitary Institute and the Coal Smoke Abatement Society have arranged a conference which will be held in London during the course of the present month. The subject has already attracted a fair share of attention, and has led to the introduction of numerous devices, each put forward as a sure preventive of smoke. Given careful and skilful stoking, it is possible to insure the comparatively smokeless combustion even of bituminous coals in almost any form of boiler. Mechanical stokers and improved grate construction have done much to reduce the production and emission of black smoke, but a point to which far too little attention is paid is the scientific design of boiler furnaces. Boiler makers show no inclination to adopt improved types of furnace, and boiler users continue to accept what the makers offer without protest. The tubes of a Lancashire boiler, being surrounded by water-cooled surfaces, are not at all conducive to the perfect combustion of gases evolved from bituminous coal, and the ordinary furnace of a watertube boiler is equally unsatisfactory. These and other boilers could easily be fitted with furnaces conducing to secondary combustion, thereby obviating the emission of smoke from the chimney, and utilising the calorific value of the fuel in far greater measure than is ordinarily attained. The average boiler user is far too prone to resort to air-dilution and steam-mixing for the purposes of avoiding fines, forgetting that the attenuation or disguise of black smoke effects no real diminution of nuisance and no reduction of the coal bill.

THE NEW COAL ELEVATOR ON THE MERSEY.—A floating elevator which has been adopted in Liverpool for coaling steamships appears to give very satisfactory results. The apparatus consists of a barge, with a capacity of 1,000 tons, having a series of false floors capable of being tilted to any angle, so that the coal may be shifted to the centre, where it is raised by a bucket elevator, discharged into an automatic weighing machine, and finally delivered through a cylindrical shoot into the bunkers of the steamer to be coaled. Practical experience shows that this appliance is capable of delivering and weighing coal at the rate of about 170 tons an hour.

ITALY AND WIRELESS TELEGRAPHY.—The correspondence between Mr. Marconi and the Italian Government which has recently been noticed in the press has a certain international importance, and is of special interest to this country. The Italian Government some time ago entered into a contract with Mr. Marconi whereby an exclusive licence for fourteen years was granted to the Marconi system of wireless telegraphy. This seems to have caused displeasure in some quarters—Italy evidently has its "croakers" just as England has — and something like an agitation against this grant of a monopoly was set on foot in a considerable number of Italian journals. Mr. Marconi thereupon wrote to the Italian Minister of Posts and Telegraphs

with reference to this criticism, and offered on behalf of himself and his companies to allow the Government to consider the agreements as cancelled in case the Government should consider them in anywise disadvantageous at the present time. In the event of the agreements being cancelled Mr. Marconi further offered to return the sum of about 25,000 lire which he has received from the Italian Government for travelling expenses of himself and assistants during the past three years.

The Government reply begs Mr. Marconi not to trouble himself about "any discordant opinion which certainly does not reflect either the feeling of the country or that of the Government," and states that the tenders for the work for the Coltano station are now being invited. "The Ministry in thus putting into execution the Bill twice approved by Parliament, is also convinced of the value of the conditions entered into, and also grateful to the illustrious Italian who generously conceded to his country the use without compensation of the extraordinary fruits of his genius."

Now it is, no doubt, natural that Italy should be favourably disposed to a system which has been developed by one of her own sons, but this decision has a deeper significance than might at first be supposed. It will be remembered that a Wireless Telegraph Conference was held at Berlin two years ago at the suggestion of the Emperor William, when various proposals for mutual working between the different systems were made and discussed. The representatives of the continental systems were anxious that all the different systems should be bound to receive messages transmitted by other systems—that is, that there should be compulsory intercommunication. The British delegates, representing the Marconi system, refused to agree to this proposal, as they regarded it as being likely, if accepted, to give their continental rivals the benefit of the greater efficiency which they claim for the Marconi system. The position of the Marconi company—such is their argument—is better than that of the foreign companies exploiting other systems: Mr. Marconi has achieved more than his rivals, but to attain to this position has involved much labour and the expenditure of large sums of money. Now when the reward is in sight, why should these rivals be given the advantage of all this labour and money by using the Marconi stations to receive their messages?

The question, it will be seen, is really a commercial one, though the proposal for compulsory intercommunication was alleged to be made in the interests of the people of the different nations. The adoption by Italy of the Marconi system is practically a complete acceptance by that country of the position taken up by the Marconi company, which will not be required at its Italian stations to receive messages other than those sent by the Marconi system. This may account to a large extent for the recent press criticism of the Italian Government contract; but the decided attitude of that Government must strengthen the Marconi interests very considerably, and certainly makes it less likely than ever that the proposal of the Berlin Conference should become an international agreement. A second conference is at present being suggested, and it will be interesting to watch the direction of the discussions which may there be raised.

THE VALUE OF PREFERENCES TO THE ENGINEERING MANUFACTURER.—Preferential trade, of the somewhat one-sided character, in which one country concedes an advantage of a tariff rebate, without receiving the advantage of similar preferential treatment, has existed between the Dominion of Canada and the United Kingdom for seven years. The effect of this is analysed by an article from the pen of an engineer which appears in a recent issue of the *Westminster Review*, under the title of "The Engineering Import Trade of Canada." The writer of the article takes the average imports, dutiable and non-dutiable, under certain specified headings during the three years immediately preceding the establishment of the preferences, and, using this as his basis, contrasts the average values of the imports in the same classes in the two succeeding triennial periods. About a dozen tables are given, which our space does not permit of our treating. Reference may be made to those which deal with the total trade. In the three years ending in 1897 the average dutiable imports from the United Kingdom amounted to about £500,000. In the three years ending 1900 this had increased to £646,000, and at the end of 1903 to £1,060,000. Gratifying though this seems, the increase in American imports of an engineering nature is much greater, the figures being as follows:—Three years ending 1897, £1,440,000; three years ending 1900, £3,207,000; three years ending 1903, £4,363,000. Despite the preference, while British trade increased by 200 per cent., American trade increased by 300 per cent. The writer of the article regards preferences as "very disappointing" in their result. He concedes, however, that

"it may be that preferential duties have prevented a greater loss of ground." Evidence in favour of this view is to be found in the state of affairs revealed by the table, which gives the average value of non-dutiable engineering articles imported. In the three pre-preferential years ending in 1897, the value of the imports from the United Kingdom was £430,000; in three years ending 1900 it had increased to £470,000, reaching £754,000 or an increase of 175 per cent. by the end of 1903. From the United States the average imports were less than those from Great Britain for the three years ending 1897, being valued at £353,000; but for the three years ending 1900 they had risen to £1,205,000, reaching £1,936,000 for 1903, an increase of 550 per cent.

One reason, perhaps, for the preferential rebate of one-third of the duty paid not giving much assistance to British manufacturers of dutiable articles, is the extremely unscientific basis of the rebate, when it is remembered that the *ad valorem* duties range from 5 per cent. on wrought-iron boiler tubes to 35 per cent. on springs and axles, that bars or plates or sheets of tin are charged 10 per cent., and manufacturers of tin 25 per cent. Mining machinery and textile machinery (when imported by Canadian spinners or weavers) are free, while steam engines and boilers pay 25 per cent., and locomotives 35 per cent. No rebate is allowed on goods exported from the United Kingdom which are not of British manufacture.

Preferences are of no value to the manufacturer of goods entering on the free list, and a rebate of one-third of a 5 per cent. duty is not so appreciable an advantage to a British manufacturer that he should wax enthusiastic concerning them. To the manufacturer whose transatlantic or Teuton rivals are faced with 35 per cent. customs duties, a rebate of one-third of 35 per cent., or 11⅔ per cent. of the value of his goods, is an acceptable concession. These obvious inequalities cannot but react against the preferentialist movement in this country. Whether it be possible to design a scientific preferential tariff which should satisfy all manufacturers in both the Dominion and the United Kingdom, and the consumers in Canada, is open to some doubt. Present disappointments are, no doubt, due to the fact that the preference now granted is arbitrary and insufficient. Whatever their political opinions, all our readers will find themselves in agreement with the concluding words in the article to which we have drawn attention:—". . . the British manufacturer should work out his own economic and industrial salvation by emulating Teutonic attention to detail and Yankee pushfulness, accepting preferences if he is satisfied that the greatest good of the greatest number is so served, but by no means relying on these alone to maintain his hold on his markets."

THE FLOW OF METALS AT TEMPERATURES BELOW THEIR MELTING POINTS.—It is very often said that the discussion on certain engineering papers read at different institutions is more valuable than the paper. While this cannot be said of a paper by Mr. Sherard Cowper-Coles on "The Metallic Preservation and Ornamentation of Iron and Steel Surfaces" before the Society of Engineers on November 6th last, the discussion which followed was, from the point of view of the physicist, potential of much interest. In his paper the author had described various methods of galvanising iron, such as dipping sheets of iron into a zinc bath, and electrolytic processes of depositing the zinc, and finally the new dry galvanising or "Sherardising" process was described. In it the article to be zinc-coated is first freed from scale or oxide, and then placed in a drum containing zinc-dust, the drum being heated to a temperature of 500° Fahr. for a few hours. The point of particular interest is that iron and steel can be coated with the new process at a temperature considerably below that of the melting point of zinc. Micro-photographs reveal the fact that between the pure zinc of the external coating and the iron or steel of the body which is coated, there exist two distinct alloys. Adjacent to the pure zinc, but clearly demarked is an alloy of zinc and iron, in which the zinc predominates. Adjacent to the iron there is an iron zinc alloy, whose boundary on the iron side is not easily distinguishable. It is manifest that the zinc cannot have melted, as, quite apart from the temperature being too low, it is impossible under such conditions to reduce the zinc dust to the metallic form. Dealing with this point one speaker suggested that differences of molecular vibration in the zinc and in the metal being coated might afford an explanation of this curious molecular intertwining. Different metals had different specific heats, and different co-efficients of expansion. Their molecular vibrations being different at any given common temperature, this peculiar flow might arise. The suggestion of this hypothesis might have gone a stage further, and urged that while differences

in the rate of molecular vibration would permit the flow of the zinc particles into the interstices, the flow might actually be occasioned by electrostatic action. In air at ordinary temperatures two dissimilar metals placed in contact become oppositely electrified, the one positively, the other negatively. The attraction which is exerted by two oppositely charged bodies, is borne in upon a student in the days when his attention is given to pith-balls and electroscopes. We are constantly extending our knowledge of the sphere in which different natural laws operate. It may be that in this case electrostatic attraction plus molecular vibration may account for a phenomenon for which the laws concerning the melting points of metals do not provide an explanation.

WATERWAYS IN GREAT BRITAIN.—At a recent meeting of the Institution of Civil Engineers, Mr. John A. Sauer, M.Inst.C.E., read a communication on this subject.

The paper began with a short historical sketch, giving dates of inception of some of the earlier navigations, and also describing such improvements as have been made in recent years. The author then went on to discuss the comparative advantages of waterways and railways, and their main differences of construction and use. He pointed out that where up-to-date canals are owned by independent companies they can in many cases show a reasonable profit, but where the railway companies own them the profits appear to be much less.

He next dealt with the difficulty of working through traffic on account of variations in gauge, and showed how, if a standard gauge could be fixed upon, the means of communication would be vastly improved. The question of a standard gauge was discussed, and the author gave his opinion as to the best standard to adopt, in view of the existing arrangements in this country. In this connection, longitudinal sections, showing the mileage and heights above sea-level, were given of the following main routes:—Hull to Liverpool: Liverpool to Midland District: Bristol to Midland District: Hull to Midland District: London to Midland District.

There were also tables showing the necessary measures for, and giving the probable cost of, improving the connections between the main ports and the Midland District. Water-supply and towing were then considered, the various means now available being described, and reasons for and against different proposals being given. The relative merits of railways and waterways as to speed of travel, were also discussed.

Mr. Sauer then dealt briefly with the question of tolls and charges, and the cost of upkeep, showing how difficult it is to compare the costs of different systems.

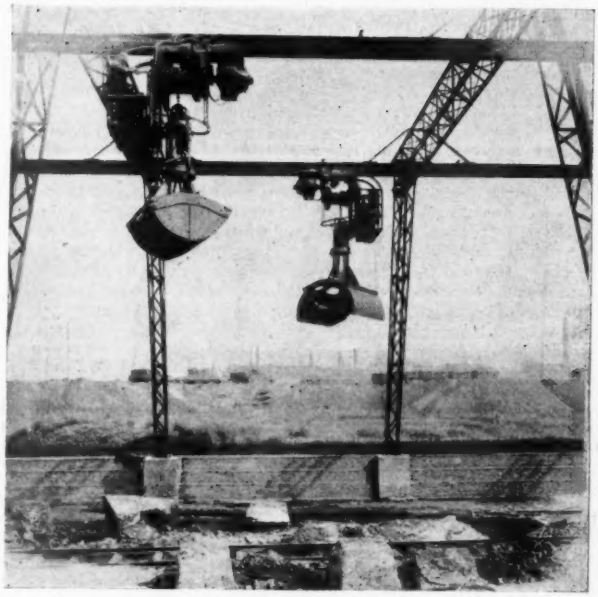
Finally the paper described the best routes for ship-canals across country, and concluded by discussing the different ways of raising the necessary money for reconstructing the waterways.

The discussion now in progress on the subject will be watched with much interest. Considerable difference of opinion is expressed by the commercial and the railway interests respectively as to the financial success of any project for restoring our derelict canal system. While firmly convinced that efficient inland navigation would be for the ultimate advantage of all classes of the community, and even for railway companies, we fully recognise the fact that the work of remodelling the canals so as to insure commercial success involves many problems that can only be solved in a satisfactory manner by the aid of engineers. For instance, it would be perfectly easy to enlarge the section of the various channels and to build new locks of adequate size for the larger vessels that ought to be employed. But locks of greater size mean increased consumption of water, a commodity that is becoming more difficult to secure every year owing to the annexation of available collecting areas by local authorities. Hence, one very important question is whether the operation of canals by means of lifts or equivalent devices would be likely to pay in districts where water cannot be provided in sufficient quantities for canals of large size. This is only one of many points upon which the public will expect enlightenment from the discussion to which we refer.

A NOVEL TEMPERLEY TRANSPORTER INSTALLATION.—An interesting transporter installation for unloading coal from vessels is at present being carried out on the Continent by the Temperley Transporter Co. The notable feature of the plant consists in the employment of electric crabs, the details of which are shown in the accompanying illustrations. The coal after being removed from the vessel is taken either direct to the mixing towers, which are situated about 750 feet inland from the quay, or is put into the long coal store over which the beams extend and afterwards taken out again to the mixing towers or into the railway trucks alongside the store. One crab works on the single beam which extends a distance of 30 feet over the water and by

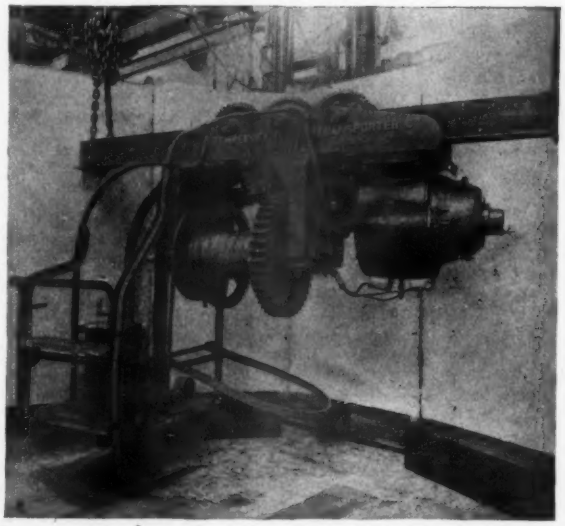
means of a self-filling crab, unloads the coal and delivers it into a hopper at the end of the two store tracks at the rate of 50 tons per hour. From there it is tapped into automatic dumping skips and taken by two similar electric crabs either into the stores or mixing towers as required. The latter crabs are also fitted with self-filling grabs by means of which they rehandle the coal from the stores.

The whole of the structural work is of steel and so designed that it can be covered in to form a closed coal store if desired.



NOVEL TEMPERLEY TRANSPORTER INSTALLATION.

London County Council Tramways.—At the present moment when the London County Council are on the verge of entering into engagements for expending between four and five millions for electrification of their Northern system of tramways, it is surely wise that the possibilities of surface contact traction should be fully taken into account. We quite agree with the reasonableness of the objection entertained by the council against overhead traction in the streets of London, but we strongly object to the unnecessarily expensive form of the conduit system installed upon their Southern lines. Our present issue contains an able article on "Surface Contact Traction" in which the subject is treated in a thoroughly impartial manner, and our opinion is that the author has made a very strong case for the general method of traction which he discusses. The article deserves serious consideration by all members of the County Council, among whom we are glad



ELECTRIC CRAB: TEMPERLEY TRANSPORTER INSTALLATION.

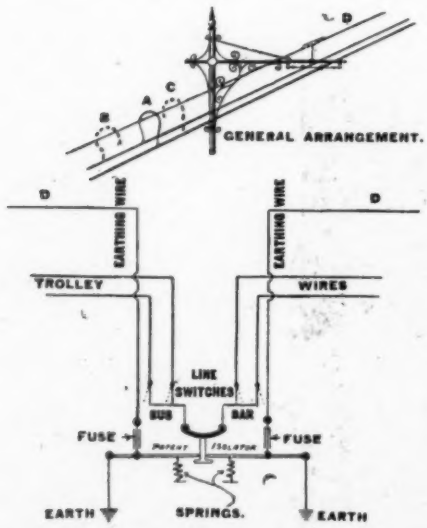
to find there are some who already feel doubt as to the wisdom of extending the previously adopted type of the conduit system to the lines on the Northern side of the Thames.

THE MOTOR CAR INDUSTRY.—Notwithstanding the growing importance of motor car imports evidenced by the recent Board of Trade returns for the first ten months of the current year, the home demand is so great that manufacturers are barely able to supply orders. In one sense this is a very satisfactory state of things, but we trust that engineering firms engaged in the industry will be able to make such arrangements as are necessary to keep the importation of foreign vehicles within more reasonable limits. There is no reason why motor cars and parts should continue to be imported at the rate of £3,600,000 per annum, and still less reason for the increase, at the rate of over £850,000 per annum, that has taken place since the beginning of the year.

RAILWAY MOTOR CARS. — Among the enterprising companies who have inaugurated motor car services on their lines, the London and South-Western Railway occupy a prominent position. The first service of the kind commenced on the Fratton and Southsea line was supplemented last year by others between Eastleigh and Fareham, and from Plymouth to Plymstock and Turnchapel. We understand the directors now propose to establish five other motor services in the West of England, and for these Mr. Drummond has designed an improved type of steam rail motor capable of attaining a speed of nearly 50 miles an hour and of carrying a load of 65 tons.

Isolating Device for Trolley Wires.

A SIMPLE and automatic apparatus for cutting out a section of trolley wire under conditions which commonly exist in practice is illustrated diagrammatically in the accompanying illustration. It will be seen that a guard wire mounted on porcelain insulators is run over and above the trolley wires. This guard wire is connected at its respective ends through two low capacity fuses to earth. Immediately a trolley wire breaks it is brought into contact with the guard wire, which in turn being rendered alive, blows the low capacity fuse in each of the two section pillars, which in turn operate an automatic switch. In order that only a very small current shall be required to disconnect the line, a special fuse is used, consisting of a tube of glass, through the bore of which a fine-drawn fuse wire is passed. In the centre of the tube is a small explosive cartridge. When an excessive current passes through the fuse wire the cartridge is exploded, the glass is broken, and the automatic switch operated.



The makers inform us that already one serious accident has been averted by the use of this apparatus, and claim for it that it cuts out a section of a falling trolley wire before the same is eighteen inches out of the horizontal, and that it will cut out a section when a falling telegraph or telephone wire accidentally drops across the trolley wire in so rapid a manner that a five-ampère fuse used to protect the telegraph or telephone instrument will not blow.

The cost of installing the apparatus is relatively small, and it can be adapted to any existing line without any derangement of the existing system.

The Local Government Board Regulations of 1904 as affecting Commercial Motor Vehicles.

By REGINALD G. L. MARKHAM, M.I.Mech.E. (late R.N.).

THE period of grace granted by the latest Local Government Board regulations covering the use of "heavy motor cars" (otherwise the heavier classes of commercial motor vehicles), expired with the month of August, though the regulations came into force early in the year, and it is, therefore, fitting to consider what has been, and what is likely to be, the effect upon the commercial motor industry and upon the use of such vehicles.

But in order to gain a proper appreciation of the present position it is necessary first to review the past, since the recent Act and regulations are, in effect, merely amendments of the previous ones and the result of observations on their working. Also, the Local Government Board Regulations being, as it were, an appendix to the Motor Car Act and dependent thereon, must be considered in conjunction with that Act.

The first Act governing the use of motor vehicles was passed in 1896, only nine years ago, though the rapid progress that has since been made in the construction of mechanical road vehicles makes the time, when considered from that standpoint, seem twice as long. In those days there was no British industry, and there were very few motors in the country, while those few were mostly imported from the Continent. Consequently, the persons responsible for the framing of the "Light Locomotives on Highways Act" had very little experience to go upon even in the case of light motor cars, and so far as commercial wagons were concerned, though they may possibly have foreseen something of their future importance, there was still less to guide them. It is true that the opinions of one or two prominent engineers who were known to be contemplating the construction of such vehicles were consulted, but when it is considered how unsatisfactory the first vehicles were, and how quickly and how greatly the first designs were altered, it is only natural to suppose that the early regulations proved, to some extent at least, unworkable in practice if the industry were not to be throttled in its infancy.

Such in fact was the case, but in the earlier days, and during the continuance in force of the first Act, there was not the anti-motor bigotry which now exists, or at least it did not so manifest itself, and the officials responsible for the enforcement of the Act and attendant regulations were consequently permitted to take a broad-minded view of the situation.

It is, indeed, fortunate for the commercial motor industry that it was so, for had the regulations then in force been carried out with the rigour—to say nothing of the methods savouring of highway robbery—which is now practised, it is safe to say that not a single manufacturer would have continued, after the first year or so, when the requirements were unknown, to sink the thousands of pounds which have been sunk to the end that the British industry in this particular branch of engineering is now, as others have been before it, *facile princeps* throughout the world.

There were one or two firms experimenting in the manufacture of commercial motors when the 1896 Act was

passed, but there was little more than mere experiment at that time, consequently the new law was hailed with whole-hearted enthusiasm as an act of emancipation, and no very careful consideration was given to the effect of its several clauses.

For a time manufacturers endeavoured loyally to comply with the requirements of the regulations, the chief difficulty being the restriction of weight, and it is fair to say that the many failures and breakdowns of the earlier years were primarily due to this cause. Then, again, it was the idea to construct vehicles to carry only about two-and-a-half to three tons, the same load in fact as the average heavy commercial horse wagon, and to rely upon increased speed for economy of transport.

But it was soon found that such loads were not sufficiently remunerative, and would not satisfy potential users, and also it was evident that for loads of four tons, the standard for several years, motor wagons could not be built sufficiently strong and reliable under the three ton tare limit imposed.

It must be admitted that this three ton limit caused manufacturers to pay more attention to the selection of the very best materials and to the employment of the most careful workmanship than they would have done had the limit been considerably higher; and subsequent improvements in quality of materials with modifications in design have tended to a further reduction of weight for a given strength and power; but still the tare of the motor wagon increased by degrees concurrently with reliability until it was very considerably in excess of the regulation limit. The forbearance of the authorities on this point was commendably considerate, for, though prosecutions occurred for that the tare weight was not legibly displayed on the motor wagon, no proceedings seem to have been taken in respect of the weight itself. This is the more remarkable in view of the marvellous uniformity of the legendary tare which appeared to be 2 tons 19 cwt. 3 qrs. for every wagon in the Kingdom, though it was common knowledge that there was scarcely a single vehicle running which could get within a ton of that weight.

When, therefore, it became known that the Local Government Board was about to revise its regulations in conformity with the new Act of 1903, it will be readily understood that a great deal of anxiety was caused alike to makers and users of motor wagons. It was realised that whatever new regulations were promulgated would probably be far more rigorously enforced than the old ones had been, and if the authorities chose to assume that the hundreds of steam wagons running in the country hitherto had complied with the late weight clause they might consider that a very slight increase of the legal limit of tare would meet all reasonable requirements. And in that case most, if not all, of the steam wagons for the heavier loads then running would have been prevented from continuing in use.

This brings us, therefore, to a point in the new regulations whose effect has been popularly misconstrued; and the misconstruction has been fostered by the motor Press, which should have known better, possibly from an unnecessary fear that the development of the heavy motor vehicle industry might be checked if the public knew the facts. The old limit of tare weight had been three tons; the new regulations permitted five tons; and the Press at once united in telling us here was a boon! They said that the old limit was a serious handicap—which was true—and that the extra two tons would permit of heavier wagons and greater powers being employed—which is not true.

Without considering for the moment the effect of other provisions of the new weight clauses, it is of interest to note that the revised tare limit, instead of promoting the anticipated increase in the weight of new vehicles, has resulted rather in more than one or two manufacturers turning out a *lighter* design as their new standard type. In several cases in fact, with the wider and consequently heavier wheels required by

the new regulations, it has been a matter of some difficulty to scale down existing steam wagons to comply with the weight clause. The fact that vehicles have been in use which exceed the present legal weight is evidently recognised by the Local Government Board regulations, which make special provision for those which were registered before 1st September, 1904. This provision, however, while it is necessary in fairness to the owners of such wagons weighing between five and seven tons, at once creates an anomaly, for while five tons is the legal limit, there are a considerable number of steam wagons permitted to run whose weight exceeds that limit.

The articles relating to the weights are perhaps the most important as affecting the use and construction of commercial motor wagons, and these regulate the total weights upon the axles as well as the weight of the vehicle unloaded.

It is laid down that the maximum weight per axle must not exceed eight tons, while twelve tons is permitted as the gross weight of the vehicle and load.

Now taking the hitherto usual practice of the leading steam wagon makers, the standard vehicles weigh very little, if anything under five tons, and the distribution of weight between the axles unloaded is about in the proportion of three to two. That is to say, the weight on the rear axle is three tons. The carried load, if evenly distributed over the platform, comes practically entirely on the rear axle; consequently the load in this case is restricted to five tons, making the total axle weight up to the limit of eight tons. But with the vehicle weighing five tons and with five tons of net load there is still two tons to spare before the total *gross* weight permitted to the wagon is reached, and this appears to be useless.

Now many people wish to carry more than five tons, and in fact steam wagons have been running for years carrying loads of six and seven tons. Assuming that a wagon of five tons tare is sufficiently strong and powerful to carry the seven tons of load which would bring the gross weight up to the permitted twelve tons, some modification of design is necessary in order to keep within the limit of load on the back axle.

Since there is no likelihood of the load on the front axle approaching the limit, the rear axle might be placed further back (the overall length of the wagon remaining the same) and thus a proportion of the carried load would be thrown upon the front axle; or both axles might be moved back with the same result but with the added effect of the overhung weight forward of the front axle decreasing, by counterpoise, the load on the driving axle. The former method is unsatisfactory because it increases the length of the wheel base, which means unhandiness in turning and manœuvring—an important consideration. Moving back the front axle presents other difficulties. In the majority of steam wagons the necessity for the axle clearing the boiler grate cleaning arrangements, whether dropping firebars or otherwise, limits the position of the front axle to some extent, for were it placed behind the boiler it would be inconveniently far back. And there is another point to be considered. Many steam wagons, for a considerable portion of their time, are required to run "light," *i.e.*, without a carried load, and any lessening of the proportion of the weight (unloaded) on the back axle must be accompanied by a corresponding decrease in the adhesion resulting in increased slipping of the driving wheels—a trouble known probably only too well to all users of commercial motors under certain conditions.

So far as steam wagons are concerned there seems to be no really satisfactory solution of the difficulty, though it is interesting to note that the latest manufacturers to enter the industry, and whose designs do not include boilers of the locomotive type, are generally placing the boilers forward of the front axle.

In general then it may be assumed

that until the regulations are amended the loads carried by steam wagons cannot much exceed five tons (unless careful attention be paid to the *method* of loading, as will presently be shown), and that the maximum gross load will never be reached.

But the end of this complex weight question is not yet, for in spite of the series of "definitions" in Article II. it is not at all clear what is meant to be included in, or what may be legally excluded from the tare weight.

To the mere lay mind which cannot understand the whole why and wherefore of legal equivocation, it seems strange that points in the old regulations which were the subject of constant conjecture should have been repeated in the new without explanation.

Thus we are told that the expression "weight" means "the weight of a vehicle exclusive of the weight of any water, fuel, or accumulators used for the purpose of propulsion," and the question at once arises—is a boiler an "accumulator"? Our worthy expounders of the law from the local benches have decided the question, but whereas one says "yes," another says "no," while a third, maybe, gives it up!

Referring to definitions and analogies in a large standard dictionary, it appears conclusive that the ordinary steam boiler, where steam is generated and stored for use as required, is undoubtedly an accumulator, but that, as a distinction, a flash type boiler, where the steam is not stored but is used immediately as generated, is not an accumulator. It would therefore appear that the weight of the ordinary type of boiler may be deducted when ascertaining the tare weight of the wagon, which makes a considerable difference in that case, though it does not much affect the axle weight problem.

Then again, and in the same connection, no mention is made one way or the other of the carrying platform or body, and here also authorities differ as to whether or not the weight of the body must be included in the tare weight of the vehicle.

To take one illustration of the absurdity of the contention of those who would include the weight of the body; assume that there are two similar vehicles of equal weight, both fitted with covered van bodies. In the one the van body is all built up solid; in the other, to suit the conveniences of various loads, the upper portion of the body is arranged to be detachable from the platform, so that when removed the vehicle becomes an open lorry. The first vehicle may chance to be over weight and may accordingly be refused registration, while the latter, as an open lorry, may pass the authorities without question, yet when afterwards in use with its van top in place this second vehicle will be as heavy as the first.

It may be argued that the regulations provide for vehicles being weighed when in use at any time in order to see that the legal limit is not exceeded. That is another point, and a very sore one, which is about to be considered; but Article XII., which provides for such weighing, does *not* give power to ascertain the *tare weight* at all subsequent to the registration of that vehicle.

Nevertheless, the said Article XII. is a most objectionable one from several points of view. In effect it gives permission to "a duly authorised officer of the registering authority or other council" having "reasonable ground for ascertaining whether the *axle weight* for the time being of any axle of the heavy motor car or of the trailer" exceeds the limit—it gives the officer permission to cause the vehicle to be driven to a weighing machine within half-a-mile in order to ascertain the axle weights.

Now, in the first place, who is "a duly authorised officer"?

There seems to be no definite pronouncement as yet upon this point, but it is very evident that the police may very easily be included, and, although the police is a very estimable force collectively, this regulation would place it in the power of a constable to cause a vehicle, against whose driver he might have a feeling of pique (by no means an

unknown state of affairs), to be taken to a weigh-bridge to ascertain the axle weights whenever, and as often as he thought fit, thus causing much annoyance and loss of valuable time to the owner. It matters nothing whether the regulations prove to be transgressed or not, the owner of the vehicle can obtain no compensation or redress of any kind.

An attempt was made, when the regulations were being drafted, to obtain the insertion of a compensation clause; the Local Government Board, however, in a circular to the County Councils explanatory of the regulations, remark that "it is not legally competent to include a provision of this nature in the present regulations," and they naively add that this circumstance has led them to restrict the operation of the Article to cases where the motor is within half-a-mile of a weighing machine. One wonders what the distance would have been could the advocates of this Article have had their way!

Then there is another point which may operate both for and against the owner in this matter. Assume, as has been previously said is generally the case, that the rear axle load of the vehicle unladen is three tons, and that the platform be about equally placed before and behind the axle. If the load be evenly distributed, five tons of goods may be placed on the platform without exceeding the maximum axle load of eight tons. But now suppose that the carried load of five tons, through convenience for unloading or through inadvertence, be placed so that the bulk of the weight lies behind the axle, then the load on the axle will obviously be increased beyond the limit and the regulations infringed. Whereas the contrary disposition of *the same* load might give a considerable margin of legal safety!

The moral is obvious—always load well forward.

But what an iniquitous combination of regulations which puts such power for annoyance in the hands of a person equipped with a little "brief authority" without affording any protection against the abuse of such power!

The regulation, Article VIII., as to speed is not materially modified from that previously in force so far as vehicles with metal tyred wheels are concerned, although the authorities knew that the speed of five miles an hour was habitually exceeded without complaint from any quarter. A limit of, say, seven miles an hour would have been quite low enough, for the economy in use of motor wagons over horses depends to a great extent upon their increased speed, and consequently an unnecessarily low limit is a direct attack on the continuance of their use. And besides, any attempt at excessive speed in the case of such vehicles with metal tyred wheels brings its own swift retribution in the form of largely increased repair and maintenance expenses. The fact appears sometimes to be overlooked that, unlike touring and pleasure cars, the motor wagon has to pay its way as it were.

An important concession is made in respect of vehicles whose wheels are fitted with tyres "of a soft or elastic material," and to this is due in a large measure the tremendous boom in motor vehicles for public passenger service which we are now witnessing.

The fact that the regulations differentiate between hard and soft tyres in the matter of the speed of vehicles of equal weights leads one to suppose that it is out of consideration for the roads But if this be so there is a fallacy in the reasoning, and anyway the roads and not the tyres are to blame.

It is true that upon a badly paved road, such, for instance, as much worn wood blocks, or upon uneven macadam (or that which, alas, too frequently masquerades in his name) an increase in the speed of metal tyred wheels may have a slightly deleterious effect. But upon smooth paving or good macadam no greater wear of the road results from any reasonable increase of speed.

On the other hand, rubber tyred wheels upon even the smoothest of macadamised roads mark an increase of speed to a far greater extent than do those with metal

tyres by gripping and flicking out the binding material, or top dressing where such is used.

The increased width of tyre necessitated in most cases by the new regulations is also a concession to the road authorities, and judging by past results is really unnecessary, though if that alone would satisfy the said authorities, neither manufacturers nor owners would be disposed to grumble. A remedy for damage to roads has always been available in a claim against the owner of the vehicle responsible for excessive wear, but the number of such proceedings since the introduction of motor wagons does not probably exceed a dozen at most, while it is certain that in several cases traction engines with large and very broad wheels, involving their owners in expenses up to £200 or more a year for damage to roads, have been supplanted by steam wagons resulting in a total cessation of all claims for excessive wear.

Article IX. permits an increase in the limit of width of a motor wagon or trailer from 6 ft. 6 in. to 7 ft. 6 in., and this is undoubtedly a concession of much value, for in the case of some trades the former normal platform area was too small to permit of the maximum load being placed without "stacking," which is often inconvenient, and there are reasons of construction which place a practical limit to extension in the direction of length of the loading platform.

The effect of the regulations in general, the Articles relating to weights being their principal feature, will probably be seen in a considerably increased employment of the internal combustion, or petrol engine for commercial purposes.

The last few years have seen vast improvements in this method of propulsion resulting in greatly increased reliability, and the weight of a petrol vehicle is considerably less than that of a steam wagon of similar capacity. At the same time it must not be assumed that the steam wagon is by any means defunct, for the economy in fuel where heavy loads are concerned in most cases will secure it a place for a long time to come.

The increased use of petrol vehicles will be evident rather in motors for lighter loads, such as delivery vans and public service vehicles, where the possibility of the profitable employment of tyres "of a soft or elastic material" will give them a further advantage in the matter of speed.

The tendency is manifest in the fact that several of the leading manufacturers of steam wagons have lately turned their attention to the construction of petrol vehicles also, and the advent of the successful motor omnibus needs not to be called to mind.

The most important features of the new regulations and their bearings in relation to the construction and use of commercial motor wagons have now been referred to, and the reader, in making a mental summary of these remarks up to this point, may possibly be led to infer that the regulations do not, as was expected, foster the industry in motor wagons, but that on the contrary they place such restrictions upon their use as may be calculated to act as a deterrent to their increased employment.

Such, however, is not the result anticipated by the writer.

It must be remembered that, as in the early days of the railways in this country which now form such a magnificent system of inter-communication, so in these times there is a deal of blind prejudice against the new method of transport to be combated, and the Local Government Board, in drafting its regulations, has endeavoured to satisfy two opposed parties, with the usual result that neither is content.

But the Local Government Board, by the pains it has taken in ascertaining the views of manufacturers and users, has shown that it is well disposed towards an industry of such far-reaching importance to the commercial interests of this country; and the broad-minded attitude towards commercial motors hitherto adopted in general by the local authorities responsible for the enforcement of the regulations, leads one to hope in confidence for a continuance of freedom from unnecessary persecution with a lively faith in the bounties of the future.

The New Electric Locomotives on the Valtellina Line.

By ROBERT H. SMITH, M.I.Mech.E.

THE Valtellina line created almost sensational interest among European electrical engineers upon its opening to the public towards the end of 1902. It was the first full-size attempt to solve the problem of using electric driving power upon a main-line railway for general traffic, including express and local trains, passenger and goods trains. It also used a new system of electric driving, namely, the Ganz cascade system; and it was the first example of the saving of copper in the line transmission, or contact line, by the use of so high a tension as 3,000 volts, current at this voltage being collected by the trolleys and taken direct into the three-phase induction motors.

The line is a sixty-six-mile long section of the Adriatic railway, which extends, with over 3,600 miles of track, over the north and east of Italy. It takes power by three 2,000 b.h.-p. hydraulic turbines from the river Adda at the Morbegno central station. Thence the energy is carried at 20,000 volts in the form of three-phase fifteen-period current on naked overhead copper wires to nine transformer stations, each of 300 kilo-volt-ampère capacity (except one, which has double this capacity). There are no rotary convertors, motor generators, or any sort of running machinery at these sub-stations, and each is well able to stand a five or six-fold overload for short periods without damage. These sub-stations are connected in parallel with the contact trolley line, so that not only can any one of them be cut out at any time for repair, without disturbance of the continuity of the supply and transmission of energy along this contact line, but also neighbouring transformers help each other when any one section of the railway is specially overloaded for a few seconds or a few minutes. The contact line consists of two overhead hard copper wires, the bonded running rails carrying the third-phase current. The collector, or trolley, consists of two co-axial straight horizontal steel tubes, covered with electrolytically deposited copper and running in roller bearings on the upper ends of a braced steel-tube frame-pole. The current does not pass through the roller bearings, but through a collar contact of carbon and gun-metal. Three and a half years' running shows no measurable wear of the trolley wire: nothing more than the polishing of its under surface. So far experience shows that the copper covering of the steel-tube rollers requires renewal after from 12,000 to 25,000 miles run.

The line was electrified as an experiment to test the suitability of the system for application to much longer lengths. Such an experiment is always, in some respects, bound to be in a certain degree inconclusive, or, at least, liable to varied interpretation. The old rolling stock must be utilised to the utmost practicable extent, and the new rolling stock must be designed so as to work in gear with the old. The bulk of the rolling stock must of necessity be passed on from the electrified section to the rest of the railway system which is still worked by steam. Nothing can be designed exactly as it would be if the whole network were electrified.

The first plant placed on the line consisted of ten electric motor-cars, to be used with trailers of the old rolling stock, and two electric locomotives intended mainly for goods traffic. The motor-cars were each furnished with four motors, gearless, or direct-coupled to the wheel-axle, and designed for two limiting speeds: accelerating up to twenty miles per hour with the motors working in cascade pairs, and from twenty up to forty miles per hour with the two secondary motors cut out. Each motor is of 150 rated horse-power, giving 600 h.-p. at twenty and 300 h.-p. at forty miles per hour; but in practice they ordinarily work up to double this power, hauling 180 tons total at forty miles per hour, or one motor-car with a maximum of ten to twelve ordinary railway carriages as trailers.

The first locomotives had each four similar gearless 150 h.-p. motors direct coupled on the four driving axles, but not connected for cascade working, and designed for a

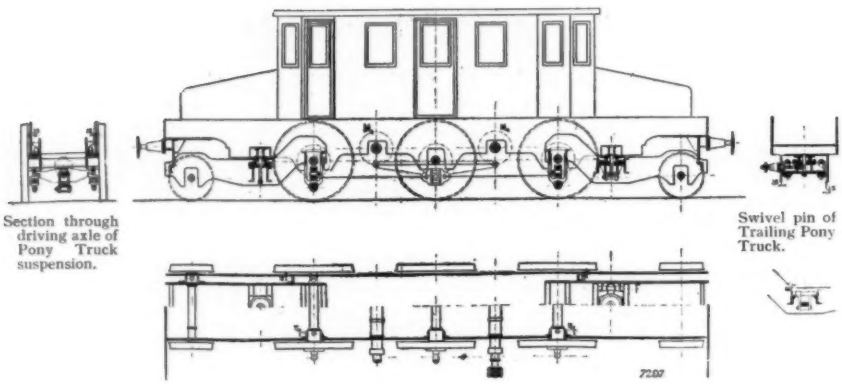
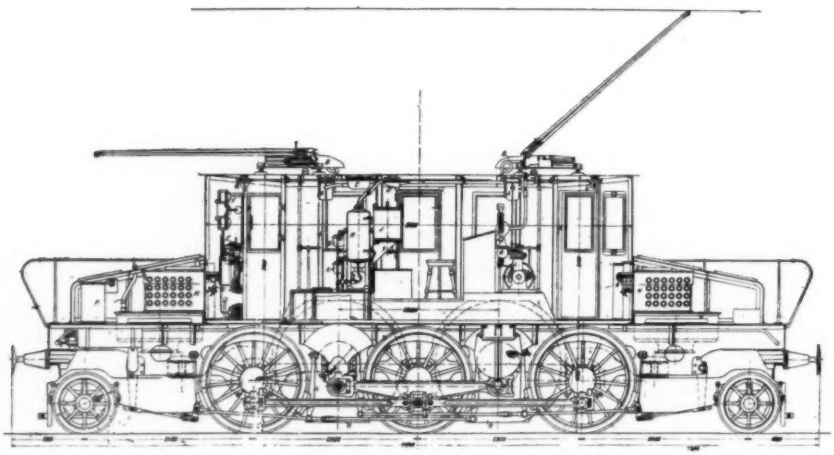


FIG. 1.—GENERAL ARRANGEMENT OF THE NEW LOCOMOTIVES.



A Main fuses.
B Trolley base.
C Choking coil.
D Distributing box.
E Master controller.
F Measuring apparatus.
G Trolley controller.
H Primary switch.
J Electric controller
K Relays
L Compressor.
M Oil separator.
N Water rheostat.
O Automatic governor of the rheostat.
P Transformer.
R Twin motor.

FIG. 2.—ELEVATION OF LOCOMOTIVE.

speed limit of twenty miles per hour. These locomotives weigh forty-six tons each, and give a tractive force of eight tons at twenty miles per hour.

Liquid starting rheostats are used with multiple metal contact plates of specially designed form. The liquid is driven by compressed air out of a reservoir box into what may be described as the resistance box; as it rises in this latter it covers a larger and larger area of the contact plates, and so cuts out resistance. These liquid rheostats are less bulky and of less weight, stand a much greater overload without injurious overheating, and cost less in repairs than do metallic rheostats; and they give a continuous instead of a step-by-step variation of the resistance, and therefore a smoother acceleration of speed.

During the second year of working, when the growth of traffic necessitated the consideration of the best method of increasing the electric rolling stock, it was determined to extend by increasing the number and power of the locomotives rather than by adding more motor-cars. The new locomotives were to be suitable for passenger express as well as for goods traffic, and were to utilise the cascade system of connection of the motors. One intermediate design between the first and that now adopted, and about to be described in this article, was worked out; but interest is now concentrated upon this latest plan, which is reported to have given practical satisfaction, several locomotives of this pattern having done good work on the line during last and the present years. The first was put in operation in June, 1904, and others in September of the same year.

The reasons for preferring locomotives to motor-cars were various, but the two most important and finally determining reasons were the following:—

First, locomotives evidently give much greater facility in the transfer of trains to and fro between the electrified and the steam-driven sections of the railway system. This is specially important because the Lecco district is the chief seat of the Italian silk growing district, and the consequent goods traffic out from, and into this district is relatively large. Also, the electrification of the whole system cannot be completed for many years to come, partly because, in Italy, there is no superabundance of free capital to be found for such large undertakings. Secondly, locomotive driving brings the whole of the electrical apparatus immediately under the continuous observation and direct control of the driver, leaves it accessible at all times for inspection and small repairs, and makes it easy to frame it entirely in noncombustible material and to separate it absolutely by noncombustible walls from the passenger parts of the train. The motors of motor-cars are inaccessible during running and accessible with difficulty while standing in a station, and the smallest repair, if effected in the sight of the passengers, has an inevitable disturbing and alarming effect. It is also impossible

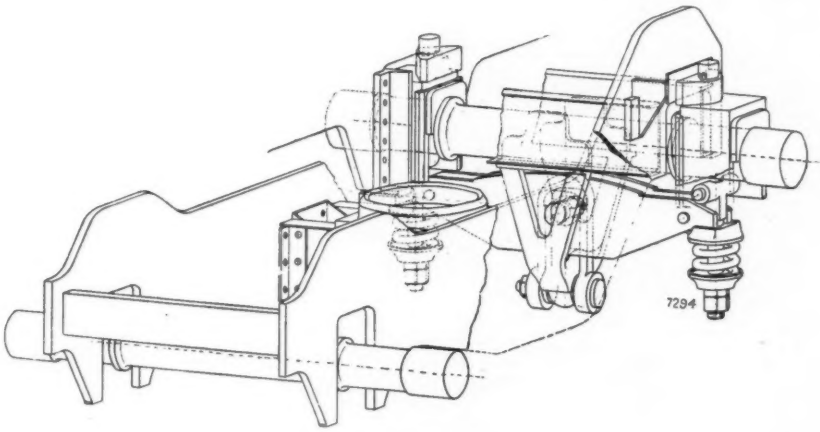
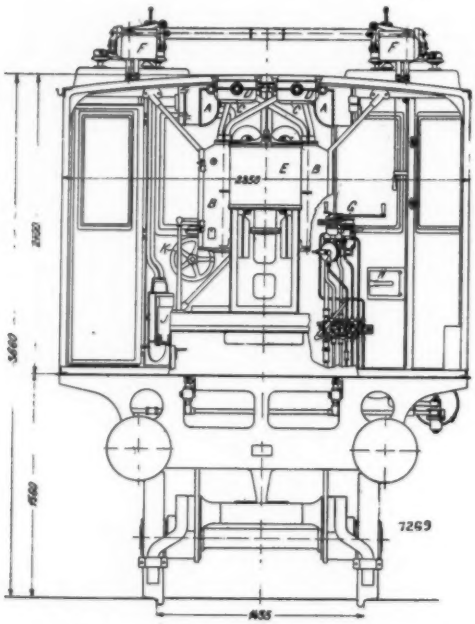


FIG. 3.—PONY TRUCK SUSPENSION.

to use the multiple-unit system where the bulk of the carriages in the trains consist of old rolling stock, which cannot, except at great expense, be fitted with the necessary communication cables and tubes for electric energy and compressed air. It may also be noted that, for given total horse-power, the motors concentrated on a locomotive are large, and those distributed along the train



A Main fuses.
B Primary switch.
C Choking coil.
D Distributing box.
E Speed controller.
F Trolley box.
G Master controller.
H Hand switch for compressor.
J Fuse box of transformers.
K Hand-brake.

FIG. 4.—ARRANGEMENT OF THE APPARATUS AT THE DRIVER'S STAND.

on motor-cars are relatively small, while one of the most fundamental laws of electro-machine construction is, that the smaller the size the less is the electro-dynamic efficiency. Owing to the absence of reduplication of the controlling apparatus the first cost of the locomotive is considerably less. Again, the withdrawal of a motor-car to the repairing shop not only withdraws the motive-power plant from service, but likewise withdraws from service a not inconsiderable proportion of the passenger-carrying accommodation.

The first locomotives are, as has been stated, gearless like the motor-cars. The rotor of their motors is mounted upon a shaft running in bearings rigid with the frame of the stator. This shaft is hollow, its inside diameter being over 4 ins. larger than the driving axle, which lies inside it and on whose two ends are keyed the two wheels running on the rails. This axle and the hollow rotor shaft are connected by a driving linkage of compact and ingenious design which compels the two to rotate always at the same angular velocity, but which allows the one to rise and fall relatively to the other. Thus the motor drives the axle by direct co-axial coupling, but the whole of the motor, including its rotor and rotor-shaft, are spring-borne along with the underframe of the bogie, the whole being, in fact, carried by one set of plate springs of normal locomotive pattern. The only load not spring-borne is the weight of the wheels and wheel-axles.

The new locomotives are also gearless—that is, the wheel axles run at the same rotary speed as the motors. In them, however, there has been substituted for the above driving linkage a double set of cranks and coupling rods. The general arrangement is shown in Fig. 1, in elevation, plan, and cross section. There are two pairs of motors, each connected in cascade, each pair mounted side by side on one shaft running in rigid bearings in the frame. These are marked M_1 and M_3, in Fig. 1. These motors lie midway between the three driving axles, but with their centres about 9 ins. higher in level than the wheel centres, thus giving room for an outside stator diameter 18 ins. greater than if direct coupled to these axles. The two motor shafts are cranked and coupled directly by a pair of very stiff coupling rods. The rigidity of these rods may be recognised from Fig. 2, where they are seen to be of deep fish-bellied beam pattern. The weight and centrifugal force of each such side-rod are balanced by two balance weights, one on each motor shaft, there being four such balance-weights, and these also balancing, of course, the motor-shaft cranks as well as the side-rods. The middle of the length of each rod is fashioned as a slotted cross-head, and in this slides the block for the crank-pin of the central wheel-axle. This

axle, therefore, follows truly the rotation of the two motor shafts, which are maintained in exact synchronism. Moreover, on this central driving-axle nothing but horizontal driving force is exerted, no vertical component existing except a small frictional cross-head resistance. The two sets of cranks at the two sides of the locomotive are at 90 deg., and driving dead-points are avoided. The plan of Fig. 1 shows that these cranks and side-rods lie outside the frame. This heavy side-rod has, at either side of the hornplates forming the cross-head slot, two wings which are pin-jointed to secondary coupling rods running fore and aft to the leading and following wheel-axles, which are thus also driven without dead-points. These secondary coupling-rods also exert pure horizontal driving forces upon the wheel crank-pins. Thus the driving creates no vertical force whatever to produce rail hammering or pitching of the locomotive.

All three driving axles are free to move vertically in their respective hornplates, and each driving axle is free to tilt laterally and independently, without such tilting straining any of the driving mechanism in its joints and members.

Driving from induction motors through coupling rods has been used also by Brown, Boveri & Co. on the Burgdorf-Thun Railway; but in these cases the motors have been high-speed geared motors and have not used the cascade connection. They have also been of relatively small size and and power. The objection to gearing increases rapidly with the horse-power, and generally what is possible on tramways is no guide at all to what is possible for heavy railway traffic. It is to be noted that induction motors of any class involve the use of a very small air space between stator and rotor, and this demands the maximum possible rigidity and freedom from vibration in the frame carrying the two, and in the fixture of the rotor-bearings in that frame. With induction motors, some form of flexible driving coupling is a mechanical essential.

The driving coupling of the first Valtellina motors, which was the design of Mr. Czerhati, worked well; but the general arrangement gave trouble in respect of dismounting for repairs, for which purpose it was necessary to press the wheels off their axles.

The new arrangement of coupling rods was suggested by Mr. Gölsdorf; and it should be mentioned that most of the data for this article have been supplied direct by Mr. Valatin, who, under Mr. Kando, has been throughout engaged on the designs of the Ganz cascade system.

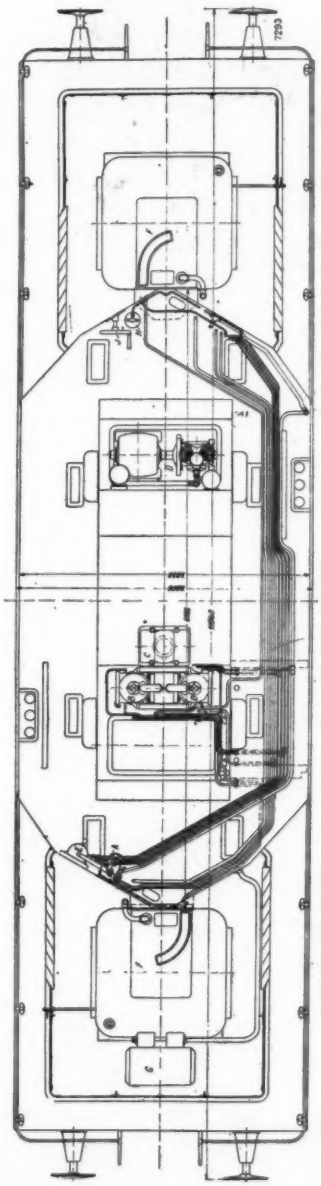


FIG. 5.—PLAN OF DRIVING GEAR.

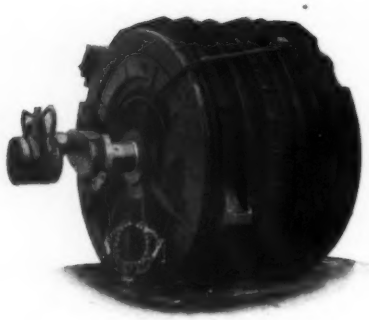


FIG. 6.—TWIN MOTOR.

Beside the three driving axles the new locomotives have leading and trailing pony trucks, each carrying one axle and one pair of wheels. These are of 850 mm. diameter, while the driving wheels are of 1,500 mm. diameter. The total weight of the locomotive in working order is sixty-two tons, of which forty-two tons is nearly equally distributed over the three driving axles.

It is to be noted that in this driving mechanism the balancing is perfect, there being no reciprocating parts as in a piston motion: all the parts move in true circular paths (combined with the uniform linear motion of travelling translation) and with uniform angular velocity. The cranks on the driving axles and the secondary coupling rods are balanced in the usual way by balance segments in the wheels. All load, except the driving wheels and axles and the secondary coupling rods, is spring-borne.

The motor slip-rings are placed outside the frames, and are therefore perfectly accessible for frequent inspection; and each motor can independently be slipped out of the frame and replaced by another like motor while it is in the repairing shop. The locomotive runs equally well in either direction.

The secondary side-rods have spherical crank-pins, and the leading and following driving axles are each given one inch side-play in their axle-boxes.

Fig. 1 will serve to explain the construction of the pony trucks. The swivel pin is placed somewhat nearer to the inner end where the truck rests on the driving axle than to the outer end where it rests on the pony axle. At the leading end of the locomotive this swivel centre is fixed in the main frame, while at the trailing end it is given some lateral play constrained towards the central position by transverse volute buffer springs. The inner end of each pony truck is carried over the driving axle, and is suspended from the hornplates of the two bearings of this axle in the manner shown in the left-hand cross-section of Fig. 1. To the transom formed of the two end sills or cross-beams, one at either side of the axle, is bolted a strong forging which passes under the axle and forms a cradle hung by a "Hook's" joint linkage from a transverse beam consisting of two deep plates. At either end this beam is carried by coil-springs and rocking suspension links pinned to the axle-boxes, so that this inner end of the pony truck is given very free lateral motion, limited by stops to about one inch throw to each side of the centre, along with an easy spring bearing on the axle. The arrangement gives an extremely flexible wheel-base over all the five axles, and also gives the leading pony wheels sufficient guiding power. The rigid base of the system—hardly to be called a wheel-base—extends from the middle driving axle to the pivot of the truck with the fixed swivel, the driving axle within this rigid

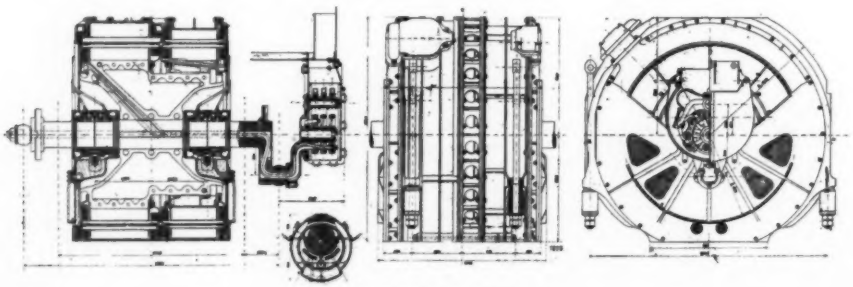
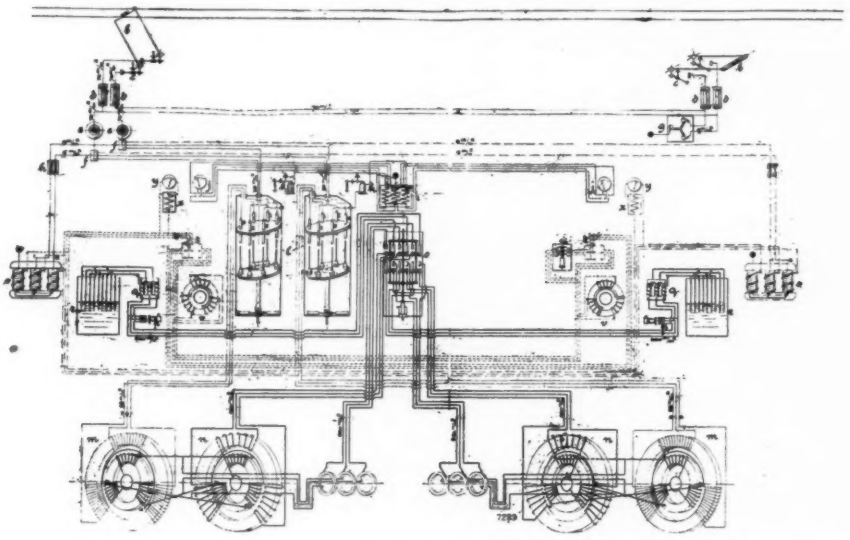


FIG. 7.—DETAILS OF MOTOR.

base being allowed one inch side-play. The pony axle carries its load by plate springs, and the load carried by the truck at the swivel-pin is distributed in constant proportion between its two spring supports at the pony and driving axles. As the design is an unusual one, a perspective view, Fig. 3, is given of the pony truck. It shows part of the transom and bolster of the swivel-joint and the rocking-beam suspension at the driving axle.

apparatus is placed for convenient manipulation in the driver's cab. Fig. 5 is a plan of the same. Identical reference letters are used here and in Fig. 2. From Fig. 5 it is seen that the inside size of the cab is 2,850 mm. wide by 6,100 mm. long.

The cascade connection of induction motors has been fully described elsewhere. Suffice it here to say that the 3,000 volt three-phase energy is collected from the trolleys and led to the stator, or primary, of the first



a a Trolley wires.
b b Trolley.
c c Trolley cut outs.
d d Main safety fuses.
e e Choking coils.
f f Distributing boxes.
g Lightning arrester.
h h Safety fuses of transformers.
i Shunt for ammeter.
j Ammeters.
k Automatic overcharge relays.
l l Primary switches.
m m „ motors.
n n Secondary motor.
o Speed controller.
p p Short circuiters.
q q Automatic governors of the rheostats.
r r Water rheostats.
s s Transformers.
t Reversing switch for compressor.
u Switch-governor of compressor.
v Compressor motor.
x Additional resistance of voltmeter.
y Voltmeter.

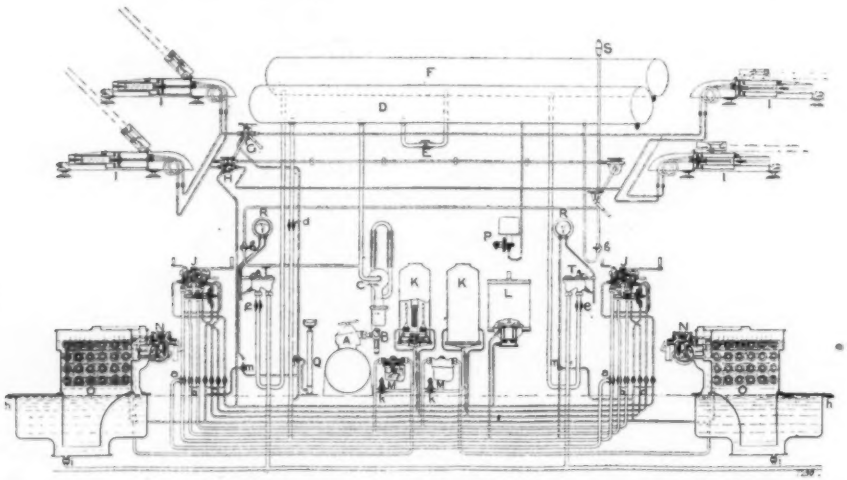
FIG. 8.—WIRING DIAGRAM OF THE LOCOMOTIVE.

As seen in Fig. 2, the total length of the locomotive over buffers is 11,540 mm. = 38 ft., and the driving wheel-base is 2 × 2,350 = 4,700 mm. = 15½ ft. The letter-references printed below this diagram and Figs. 4 and 5, make the general disposition of the electrical and mechanical parts plain. Up to the motor and driving gear it is similar to the original locomotives which have been previously discribed in several publications.

Fig. 4 shows how the starting and driving

motor direct without transformation or conversion. The current induced in the rotor, or secondary, of this motor, instead of being wasted in ohmic resistance in rheostats and in the rotor windings, is led through slip-rings to the primary of the second motor, and does useful work in driving this motor. The induced currents in the secondary of this second motor are led through slip-rings to rheostat starting resistances, which also serve to graduate and control the running after starting. The

synchronous speed of the second motor is made half that of the first. When the speed has risen to this first limit, the rheostat resistance being wholly out of circuit, the second motor is cut out: it is no longer of use because it would act as a dynamo above its synchronous speed. The first, or high tension, motor now works alone up to a speed a little less than its synchronous speed, and the regulation of the acceleration from half up to full speed is controlled by fifteen periodicity. This is the full speed of the high tension motor when run singly, the other being out of circuit. The stator of this first machine alone is wound for high tension, and it is tested at 15,000 volts; the other stator and the two rotors are wound for 400 volts only and are tested at 1,200 volts. The slip-rings are connected with the rotor of the first motor by cables passing through the hollow shaft and round the crank through special grooves and



A Compressor.
B Return valve with dash-pot.
C Oil separator.
D Air tank for the electric apparatus.
E Return valve.
F Air tank for the air brake.
G Trolley controller (direct acting).
H Trolley controller (indirect acting).
I Trolley base.
J Pneumatic master controller.
K Primary switch.
L Speed Regulator.
M Automatic relays.
N Head of the water rheostat.
O Water rheostat.
P Switch governor of compressor.
Q Hand air-pump.
R Manometer.
S Air whistle.
T Air brake valve.
a Shut-off and safety cock.
b Shut-off cocks for the two motor groups.
c Shut-off cocks.
d Principal shut-off cocks.
e Shut-off cock of the air brake.
f Shut-off and commutating cock.
g Whistle valve.
h Trying cock.
i Escape.
k Commutating valve for the primary switch.
m Commutating cock for the air reduction.

FIG. 9.—AIR PIPE DIAGRAM OF THE LOCOMOTIVE.

the rheostat inserted in the rotor circuit of this first high tension motor.

Fig. 6 gives a photographic view, and Fig. 7 a complete drawing—section, and end, and side elevations—of the "twin" motor on the new locomotives, that is, the first and second motors of the cascade combined side by side upon one shaft. Both these are 8-pole machines, so that 225 revolutions per minute would be the speed at which each would run synchronously if connected direct to the line current of bores made in the cheeks and pin, the slip-rings being mounted on a return crank outside the frame and outside the side-rods.

The windings of the two rotors are directly connected. From each of the three connections there is led off at a point between the two rotors a branch to one of a set of three slip-rings. From the slip-rings current, collected by carbon brushes, is led to the speed controller marked *O* in Fig. 8 and *L* in Fig. 9. Leads from the same speed controller go to the terminals of the stator

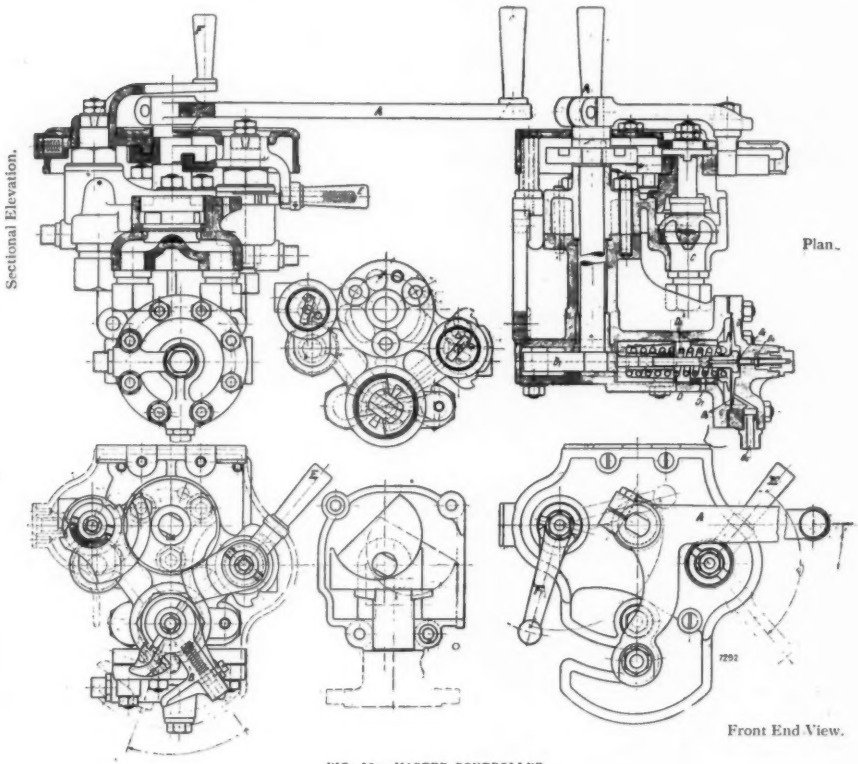


FIG. 10.—MASTER CONTROLLER.

windings of the low-tension motor. In this latter the rotor acts as primary and the stator as secondary. In cascade working the slip-ring circuits are open, being broken at the controller, and the brushes are inactive. The induced current in the low-tension stator passes through the controller to the rheostat, the resistance of which is gradually cut out as the speed rises from zero to "half speed," *i.e.*, maximum cascade speed. For further increase of speed the controller is shifted to "single-working" connection, the low-tension stator circuits being now open and those by the slip-rings closed through the rheostat. No induced currents now flow through the low-tension stator, and its rotor therefore does no work. Whatever current flows in this rotor is now wattless, its windings acting simply as choking coils. The induced current from the rotor of the high-tension motor now flows by the slip-rings through the rheostat, whose resistance is gradually cut out as the acceleration proceeds to "full speed," *i.e.*, maximum speed in single working.

The casing of the motor is built up of two main steel cylinders, stiffened by cooling ribs, a central ring giving access to the winding connections, and two end plates carrying the main bearings. This casing is slung from the frame by four bolts with spring suspension-cushions. In spite of the perfect mass balance of the moving parts, there is a rhythmical stress pulsation, owing to the driving effort through the coupling rods being alternately in thrust and in pull, and the motors require protection from this pulsation because of the very small air space between stator and rotor. The casing has two meters outside diameter, but this is reduced by flats on the four sides. The top flat is caused by the floor of the driver's cab, the bottom flat by the necessary clearance above rail

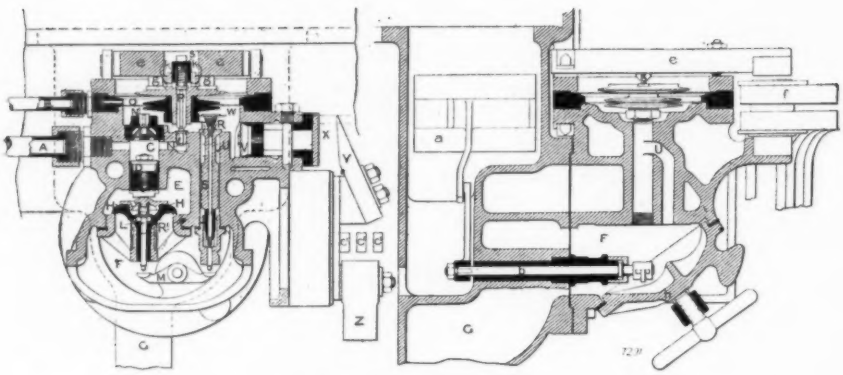


FIG. 11.—HEAD OF WATER RHEOSTAT.

level, and the two side flats by the proximity of the three wheel axles. The bearings carried by the casing come wholly inside the length of the motor windings, and leave the whole width inside the locomotive side-frames available for these windings. These bearings have ring lubrication. Immediately outside them come a second pair of bearings in the locomotive side-frames. The special function of the first pair of bearings may be said to be to keep stator and rotor exactly concentric and to carry the weight of the rotor; that of the second pair of bearings being to take the alternate forward and backward reactions of the driving side-rods.

The spider carrying the rotor core and windings is in halves bolted on the shafts. The laminations of the first motor are built in place, while those of the second motor are built upon a former which is afterwards bolted on the spider.

The brush for each slip-ring consists of twenty carbon blocks, and the brushes are mounted inside a steel box hinged in halves so that it can readily be thrown open for cleaning, &c., but gives complete protection to the rings when running.

In single gear these motors give 95 per cent., and in cascade 88 per cent. efficiency. Their power-factor is 95·6 per cent. in single and 79 per cent. in cascade.

The apparatus for manipulating and controlling the driving is almost entirely pneumatic. The compressed air for this pneumatic apparatus and that for the air brakes come from two reservoirs supplied by the same compressor. This compressor is driven by an electromotor, current to which is switched on and off according as the air pressure falls to, and ascends to, prescribed limits, the switching being automatically operated by the air pressure itself. Between the two reservoirs, which are marked *F* and *D* in Fig. 9, there is a non-return valve *E* which prevents the pressure from falling in the brake reservoir in consequence of excessive withdrawal of air from the reservoir which supplies the operating mechanisms.

Fig. 8 is a diagram of the electrical connections throughout the locomotive. Fig. 9 is a similar diagram of the air piping. Fig. 10 gives in various sections the details of the electro-pneumatic master controller. Fig. 11 gives similar details of the automatic operating-box, or "head," of one of the liquid rheostats.

The current collecting rollers are raised against the contact wires, and lowered through a spring connection by air pressure upon pistons in two horizontal cylinders which are fixed upon the well-insulated trolley base-plates on the outside roof of the cab. Shock in raising and lowering is guarded against by an oil cataract. The operating air is admitted and released by a valve of the master controller in the cab. For the two speeds of twenty and forty miles per hour, two pressures of 15 and 19 lbs. are used, the extra 4 lbs. pressure being obtained by admitting the air to the second or auxiliary piston. The pneumatic mechanism may be studied in Fig. 9. The air thrust for the lower speeds is obtained direct from the valve *G* moved by a hand lever. That for the higher speeds comes from *H* operated automatically in connection with the speed regulator *L*. There are two pairs of contact rollers, one at each

end of the cab. These are normally used for running in opposite directions, but in shunting it is often convenient to bring both into operation in passing crossings and turn-outs.

When either trolley is lowered its connection with the cables inside the locomotive and with the other trolley is automatically opened by a blade switch. This switch marked *C* is shown in Fig. 8 closed at the left-hand end, where the trolley is raised and open at the other end with the lowered trolley. Each switch is duplexed for the two phases. Thus the lowered trolley is never charged above earth potential, as the opened switch puts it in contact with the steel skin of the cab, which is well earthed.

Combined with the air valve for lifting the trolleys is a special key which locks the casing containing all bare high tension apparatus. This key can be removed from the valve and used to open this casing only when both trolleys are down. The driver, therefore, cannot get at bare high tension parts except when they are not charged.

Under the roof of the cab, and fixed to it, are the main safety fuses *d d*, the choking coils *e e*, the distributing boxes *f f* and the lightning arresters *g g*. The lightning arresters consist each of three sets of zinc rollers in star connection, two sets coupled to the two main conductors from overhead, and the third earthed through a graphite resistance. Fig. 12 is a photographic view of this lightning arrester. There are two distributing boxes, one for each overhead phase. From each box proceeds four high tension (3,000 volt) cables: two to the two transformers *s s*, which supply low tension three-phase current to the compressor motor and other auxiliary plant, and two to the two main primary switches *l l*, serving the two twin motors. All these high tension cables are placed inside steel tubes, which are perfectly earthed.

The primary switches, marked *l l* in Fig. 8, and *K K* in Fig. 9, are of the dry plunger pattern. Fig. 13 shows the appearance of the switch with the door of its casing thrown open. To make contact a disc carrying six gun-metal rods is raised by air pressure to push the rods into six porcelain tubes, through the upper end of which the main leads are cemented. The reversal of the direction of running is obtained by the simple rotation through 60° of the disc carrying the rods.

The speed controller marked *O* in Fig. 8 and *L* in Fig. 9 is duplex to serve the two twin motors. It is shown photographically in Fig. 14. Its function is to switch from

FIG. 12.—LIGHTNING ARRESTER.

cascade into single gear. It also is operated by compressed air lifting a piston whose rod carries six brushes. In the lower position these connect the stators of the second motors (which act as secondaries to the rotors as primaries) to the rheostats for cascade working. In the upper position

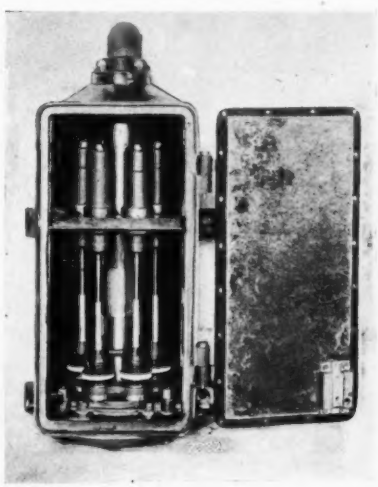


FIG. 13.—PRIMARY SWITCH.

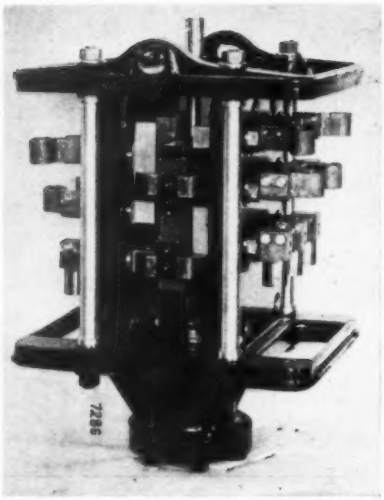


FIG. 14.—SPEED CONTROLLER.

they connect the rotors through the slip-rings with the rheostats.

On the way to the rheostat *r* the leads pass an automatic short-circuiter *p*, and an electro-magnetic rheostat regulator *q*, Fig. 8.

There are two pneumatic master controllers marked *J J* in Fig. 9. Their constructional details are shown in Fig. 10, and the external appearance in Fig. 15.

Each of the two controllers commands both twin motors with their accessories, namely, the primary switches, the speed controllers, the rheostats, and the short-circuiters; but the two are ingeniously interlocked so that either can be operated only when the air valves of the other are closed. Thus, although the locomotive can be driven from either end of the cab, two men at the two ends could not simultaneously attempt control.

Each controller has three levers. The main long lever *A* (Fig. 10) stands upright when the motors are entirely out of circuit. In the first part of its motion from this zero position *A* carries with it another short lever, which admits compressed air to the valve boxes of the primary switches and of the rheostats. This effects the closure of the primary switches, and makes the rheostats ready for starting, but not actually opening its valves. This air reaches the rheostat by the pipe marked *A* in Fig. 11. Further motion of lever *A*, Fig. 10, lifts, by means of an eccentric on its spindle, the spring D_2, which again presses upwards the diaphragm plate D_3. This again opens the small air valve D_4, this opening, however, not taking place until after the spring has been compressed to a certain degree. The air thus admitted above the diaphragm passes by the port D_5 to the rheostat heads, which it enters by the pipe marked *B* in Fig. 11. By flux of air through D_4 the pressure above the diaphragm rises until it is sufficient to compress once more the spring D_2 to the extent of closing again the air valve D_4. The air pressure required for this reclosure depends on how far the lever *A* has been moved, the extent of its motion regulating the position to which the abutment end of spring D_2 has been pushed by its cam. The position of lever *A* thus regulates the pressure in the rheostat head, and thus regulates the starting current and the acceleration. In starting uphill or against a headwind a larger current is required.

When the motion of lever *A* is reversed, after the valve D_4 is closed, the air pressure causes the diaphragm to follow the decreasing thrust of the spring until the small needle valve D_6 (formed by the end of the spindle of the larger valve D_4) opens, when a free way for the escape of the compressed air to the outer atmosphere is opened through the port D_7, and the rheostat heads are exhausted of air.

The second lever *E* is the reversing lever. It admits air which, acting on a piston in the primary switch-box, turns the base plate of this switch through 60°. It is interlocked with *A*, so that it can be moved only when both primary switch and rheostat are open.

The third lever *F* admits air to the speed controller, and thus changes the connections from cascade to single or *vice versa*. It also is interlocked, so that this change can be made only when lever *A* is in zero position.

The second and third levers *E* and *F* have no intermediate positions; each should always stand at one or other end of its throw. The interlocking prevents *A* being moved from zero position, except when both *E* and *F* are in one or other end position. It is only on the one lever *A* that the driver has to exert his faculty of variable adjustment, and the whole operation of driving is eminently simple, although the driving apparatus may be complex. It is hardly necessary to say that it is of simple construction in comparison with that of the

master controller of a multiple-unit motor-car train.

Between the master controller and each primary switch there is placed a spring-loaded valve, marked *k* in Fig. 9. The effect of this regulating valve is to delay the commencement of the closing motion in the switch until the air pressure has accumulated in the near neighbourhood of the switch, and thus to ensure a sudden closing. In opening, the commencement of the exhaust to the atmosphere is through the rheostat pipe, so that the rheostat is opened before the primary switch. This switch is held closed until the regulating valve drops when direct atmospheric exhaust takes place freely and sudden breaking of the contact results.

Fig. 11 shows the pneumatic head of the improved form of liquid rheostat, and Fig. 16 gives a general view of this rheostat, which is also seen in Fig. 9, marked *N*. The water is cooled by circulation through a series of ⊂-pipes covered with air cooling gills. The sheet iron contact plates belonging to the three phases are hung alternately, as seen at *r*, in Fig. 8, being insulated one from the other by porcelain blocks. The series of plates for each phase is varied in form and length. The automatic action of the head is regulated by an electro-magnet *q* of Fig. 8, inserted in the secondary circuit of the motor, and concurrently by the air pressure admitted. In Fig. 11 this electro-magnet is marked *f*, and its soft iron armature *e* is mounted on a knife-edge hinge, while it bears by another knife-edge *g* upon the upper and larger of the two diaphragms enclosing the space *Q*. Compressed air is brought to this space *Q* by the pipe *B* from the regulating valve of the master controller. Pipe *A* brings compressed air from the starting valve of the master-controller to the space *C*, under the valves *N* and N^1 and over the piston *D*. A float *a* lies on the water in the reservoir of the rheostat, so that the float is at its highest position when the rheostat resistance is greatest, and at its lowest when this resistance is all cut out by contact of the water with the hanging iron plates. The lever of this float moves a secondary lever keyed on the spindle *b*, and rocks the arm *M*. The position of *M* shown in dotted line corresponds with infinite or maximum resistance through the rheostat: that in full line, in which it lifts the valve *T*, with all resistance cut out. *Y* is the three-brush contact for the short-circuiter *X*, which is pushed forward into contact by the piston *V*. A valve *P* is held close by the spring *s* and, when it is opened, exhausts air from space *W* into the open atmosphere. Air pressure in *C*, acting on the piston *D*, holds down closed the valve *H*, which is pushed upwards and opened by the spring R^1. Inside this valve another small pilot valve *L* is held down close by a spring.

When all the rheostat resistance is in, the valve *T* being open, the water space is in communication through the port *U* with the space *W* under the lower diaphragm. There is also no pressure in spaces *C* and *Q*, the diaphragms are unstrained, and the valve *H* is opened with piston *D* at its top position. Since space *E* above *H* is open to the atmosphere, the rheostat water space *F*, as also space *W*, are at atmospheric pressure. The spring *s*, acting through valve *P*, also holds spring *N* closed, while the small pilot valves *L* and *R* in the centres of the large valves *H* and *T*, are also closed by their respective springs. There is no secondary current from the motors, and the electro-magnet exerts no pressure through its armature on the diaphragms.

When the starting valve of the master controller first moves, pressure reaches space *C* through pipe *A*, sufficient to push down piston *D* and close valve *H*, thus shutting off the water space from the atmosphere. But the pressure is not yet enough to lift valve *N* against spring *s*. The pressure, therefore, does not reach the water space, and the cutting out of resistance does not yet begin.

Further movement of the starting lever of the master controller carries with it the

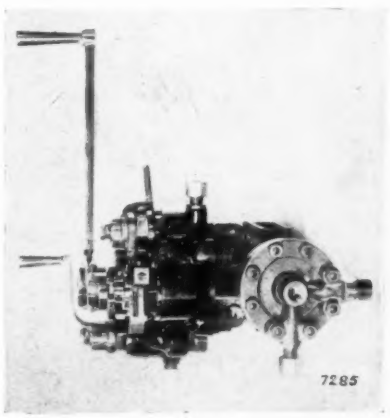


FIG. 15.—PNEUMATIC MASTER CONTROLLER.

regulating valve, and this admits pressure through pipe *B* to the space *Q* between the two diaphragms, which are clamped together at the centre, and both of which now lift, because the upper one has the larger area. This opens the valve *N* (without opening valve *P*), and space *W* is raised in pressure by influx of compressed air through *N* from *C*. From *W* this air passes by valve *T* and port *U* to the water space, depresses the water and forces it into the resistance box, thus gradually cutting out resistance. A secondary current now begins to flow from the motor and through the electro-magnet, whose armature begins to press the diaphragms downwards, so checking the motion above described. This results in the gradual re-closing of valve *N*, cutting off

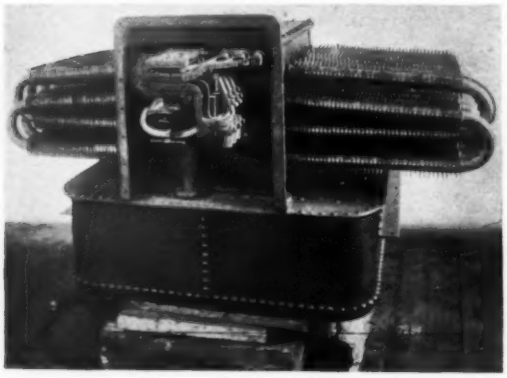


FIG. 16.—LIQUID RHEOSTAT.

supply of air to *W* and the rheostat water, and finally opening valve *P*, which exhausts the air from *W* into the atmosphere. Before this final stage is reached, the float *a* has fallen low, so as to cause the lever *M* to release and close the valve *T*, and thus close port *U*, and so retain the air already in the rheostat box and maintain the water at the level it has reached. The valve *N* lifts again because of the decrease of pressure in *W*, the diaphragm rises, the valve *P* closes, and the accumulation of compressed air in *W* drives the piston *V* forward so as to short circuit the rheostat. From Fig. 8 it will be seen that no current now flows through the electro-magnet, and the diaphragms are thus relieved of pressure from its armature.

When the motors are disconnected, the starting valve is moved back and opens space *C* through pipe *A* to the atmosphere. The valve *N* closes, but the valve N^1 opens and exhausts freely the space *W*. The decrease of pressure here leads to piston *V* drawing back under the influence of a spring not shown in the drawing, and thus the short circuiting contact is again broken. At the same time the piston *D* rises and releases the valve *H* which is opened by the pressure of the spring R^1. The opening of this valve freely exhausts the air from the rheostat, the water falls back from the contact plates, and the full rheostat resistance is once more inserted.

There remain to be mentioned the automatic relays marked *M M* in Fig. 9. The function of these is to open the motor circuit in case of dangerous overload. The apparatus essentially consists of an electro-magnet excited by the earth phase of the main current. On this reaching its permissible maximum a valve is opened which exhausts the compressed air from the rheostat and thus opens the secondary circuits so that no current can flow and no work can be done in the motors. The action is modified by an oil cataract, making the apparatus a time-relay which delays the cut-out action in inverse proportion to the intensity of the overload current.

The transformer for the air compressor motor is of the oil type and has 5 k.w. capacity. It steps down from 3,000 to 110 volts. At 430 r.p.m. the compressor supplies 520 litres of free air per minute. It operates with slide valves and is noiseless. The locomotives are fitted both with hand and with Westinghouse air-brakes. All six driving wheels are braked on both sides.

One locomotive has been put experimentally on the line, since last September, which differs from the above-described in having metallic in place of liquid rheostats. This necessitates alterations in the design of the master controller, and both rheostat and rheostat switch become very bulky structures of excessively numerous parts. The driving is also more laborious to the driver, and until we hear that the railway authorities have decided to use this system in preference to the other, we think it unnecessary to illustrate it.

Running tests on the line with a dynamometer car to measure the drawbar pull,

show in one case a drawbar pull going up to 3,000 kgs., and averaging a little under 2,000 kgs., with a train of 190 tons weight, exclusive of the locomotive, and with speed accelerating up to 60 kms. per hour in about 1,600 metres. The maximum speed was well maintained on 7 and 9½ per 1,000 up-grades.

In another case, starting on an up-grade of 1 in 50 with a train of 190 tons, or 250 tons inclusive of the locomotive, the drawbar pull varied from 5,000 to 4,000 kgs., the higher pull lasting during the acceleration up to 30 kms. per hour speed in 640 metres distance.

Another test showed the great starting capacity of these locomotives. With a train of 400 tons, thirty successive starts at two minutes intervals were made, the speed of 30 kms. per hour being reached and

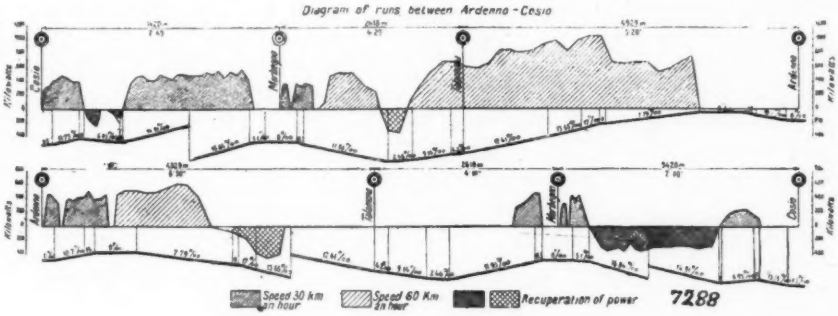


FIG. 17.—DIAGRAMS SHOWING RECUPERATION OF POWER.

destroyed in each interval. The maximum drawbar pull exerted is twelve tons, which is double that required by the specification, while this was reached with line voltage between 2,200 and 2,300, or 25 per cent. below the stipulated 3,000. The overload capacity of the motors is thus seen to be extremely satisfactory.

Fig. 17 shows particulars of a run from Cosio to Ardenno and back again, the distance between these two stations being 11 kilometres. The train loads were 286 and 280 tons. The gradients and distances are marked on the diagram, and the heights of the hatched areas measure the kilowatts consumed. The hatched areas below the datum line indicate energy recuperated by the use on down-grades, and in coasting, of the cascade connection above full cascade speed, the motors working as dynamos and delivering electric energy to the line at

speeds above 30 kms. per hour if kept in cascade at such speeds. The diagram shows that at 30 kms. per hour the kilowatts varied from 300 to 600; while at 60 kms. per hour it varied from 500 to 1,000. The maximum rate of recuperation was over 400 kilowatts. This diagram also proves a drawbar pull of 6,300 kgs. at a speed of 60 kms. per hour on an up-grade of 17 per 1,000.

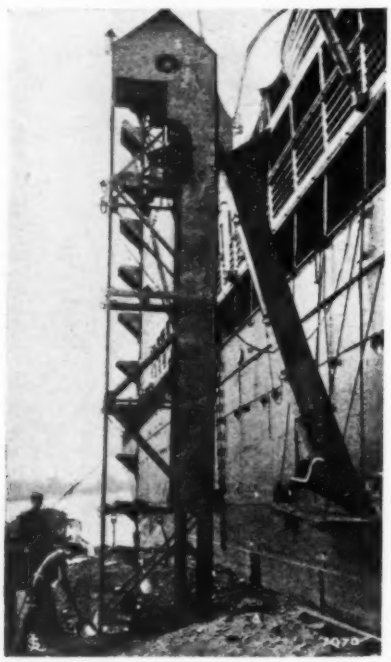
It may be interesting to mention the economic results obtained from this Ganz cascade system over lengthened periods, although the full year's accounts quoted from do not, of course, refer to the work of the new locomotives. The latest complete returns relate to the year July 1st, 1903, to June 30, 1904. In this year 47¾ million ton-miles were run, and 3·4 million kilowatt-hours were consumed at the central station. This includes all transmission and transforming losses, lighting of carriages and stations, all shunting in stations and yards, and the motor driving of the repair shop. It equals 71·6 watt-hours per ton-mile. These ton-miles involve a great deal of climbing, because on two sections of the line the gradients are heavy. It is, therefore, fair to consider the equivalent figure obtained by reducing this climbing work to an equal amount of haulage on the level. The legitimate method of making such reductions is well known. The virtual ton-miles so reckoned for the year quoted was 57½ million, and the energy consumption per virtual or level ton-mile is just over 59 watt-hours. This is a very good result, the more so when considered in view of the fact that the traffic on this line, through a somewhat remote and mountainous district on the southern slopes of the Alps, is so

much wanting in density that the central station load factor is not much over 30 per cent.

The average consumption on the train itself—excluding transmission and other losses—is ascertained by special test to be just over thirty watt-hours per ton-kilometer or 48 watt-hours per ton-mile. The consumption on the trains of the Central London Railway is given as 57 watt-hours per ton-mile. The working expenditure over the whole year mentioned above, including central station, primary and secondary lines, transformer sub-stations, electrical and mechanical repairs, up-keep and working of the rolling stock, and service on the trains, amounted to under £4,900; which equals only 2*s.* 6*d.* per 1,000 ton-miles. Reduced to per train-mile this same cost is 2·78*d.*

Apparatus for Coaling Steamships.

An apparatus for coaling steamships has recently been devised, which would appear to fill the requirements called for by modern conditions, namely, rapidity of action, coupled with high capacity, and minimum space occupied. The accompanying illustration shows at a glance the principle of the apparatus. It consists of a light, steel frame tower, about 30 ft. high, within which runs an endless steel link belt chain carrying buckets of the same material. Sprockets at each end of the frame carry the belt, the upper sprocket being driven from the shaft of a large spur wheel by means of a chain. Motion is imparted to the spur-wheel itself by an 8 h.-p. electric motor, current for which is supplied from the ship. The speed is regulated by a portable automatic release starting box. There are thirty buckets, each of which holds about 1 cu. ft. or about 36 lbs. of coal, and when running at its highest speed the apparatus can deliver 180 tons of coal per hour. The frame is suspended by tackle from a boom fitted to a socket in the ship's side, and supported by guy ropes or stays. The lower end or boot of the conveyor is in the coal barge, the coal being fed to the boot in shovels by men, who shift the barge and lower the boot as the coal is unloaded. The contents of the buckets are dumped into a chute provided with an adjustable shoe, which enters the bunker port in the side of the vessel.



FEEDING THE COAL INTO THE BUCKETS.

The total weight is about two tons, and the machine can be set up, moved, and removed by four men. Three or four machines are used at one time, each with six men, including the shovellers in the barge, and the trimmers in the bunkers.

These coaling machines are used by the American Line, and we are informed that they have handled an average of 60 tons an hour each, for sixteen hours.

Conduit Electric Tramway Systems.

By J. H. RIDER, M.Inst.C.E.

(Chief Electrical Engineer L. C. C Tramways.)

THE successful working during the last three years of the combined overhead and conduit tramway at Bournemouth, and of the extensive conduit system of the London County Council, has directed a considerable amount of attention in this country to this method of operating tramways. When the extensions now in hand on the South London lines, and the electrification of the North London lines on this system are completed, London will have probably the largest conduit tramway system in the world.

In America there are conduit tramways in both New York and Washington, while on the Continent of Europe there are several examples, notably Paris, Berlin, Brussels, Vienna, Buda-Pesth, Lyons, and Bordeaux. Several of these lines are comparatively modern, and the experience gained has been such as to warrant the statement that practically all the working difficulties have been overcome, and that, to day, a conduit system can be equipped which can be guaranteed to be a success, at any rate from the operating point of view. The question of cost is another matter which will be mentioned later.

The advantages of the conduit system are—

(1) No posts, overhead wires or contact studs in the streets.

(2) No damage from falling wires or live contact studs.

(3) Quieter running of the cars; as the noise of the trolley on the wire is obviated.

(4) No risk of electrolysis, as both conductors are insulated, and the rails are not used as any part of the circuit.

The disadvantages are—

(1) Greater capital cost of construction, and greater maintenance cost in operation.

(2) Somewhat greater risk of dislocation of service on account of foreign substances, such as hoops, &c., getting into the conduit, or through the ploughs jambing in the slots.

(3) More unsightly surface construction, at any rate so far as the centre slot system is concerned.

(4) Risk of injury to cyclists and others owing to the width of the slot.

(5) Greater difficulty in construction, owing to the number of sub-surface

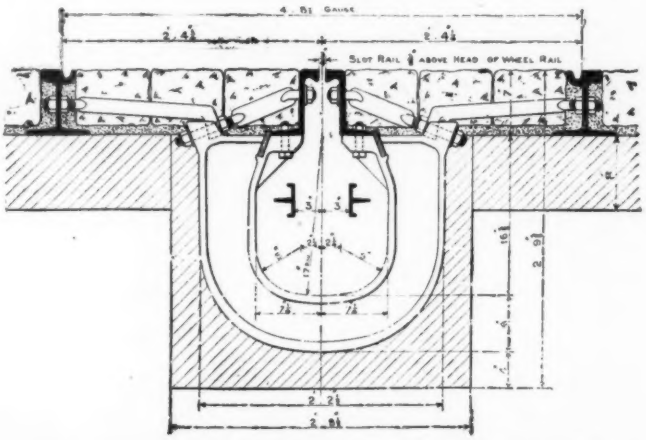


FIG. 1.—CROSS SECTION OF CENTRE SLOT CONDUIT AT YOKE L. C. C TRAMWAYS.

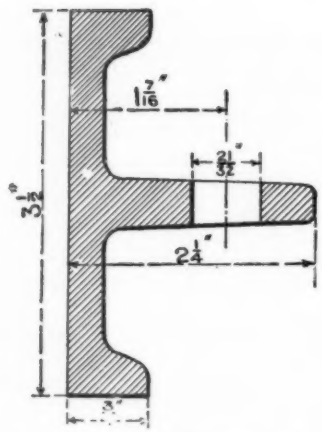


FIG. 2.—DETAILS OF CONDUCTOR, L. C. C. TRAMWAYS.

obstructions to be dealt with, and the shallow bridges which have sometimes to be crossed.

The question of cost will, in all probability, outweigh all others, and as the conduit system can only pay its way where the car service is very heavy, such as in metropolitan cities, its adoption will be confined to such places, unless, for local reasons, it be used in conjunction with the overhead system for the centres of towns such as Bournemouth.

All modern conduit systems employ two steel conductors suspended from insulators within a concrete tube or conduit, access to which is obtained through a slot on the surface of the roadway. The sliding contact between the car and the conductors is made by means of a plough carried on the car,

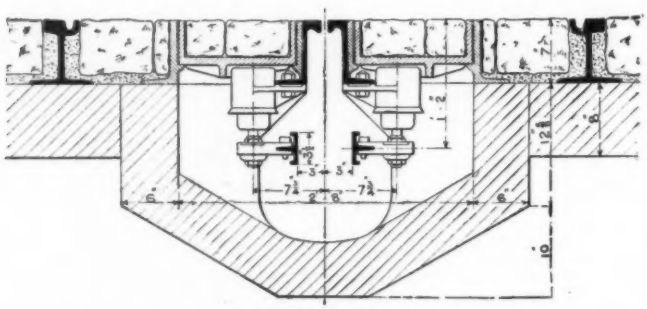


FIG. 3.—CROSS-SECTION OF CENTRE SLOT CONDUIT AT INSULATOR BOX, L. C. C. TRAMWAYS.

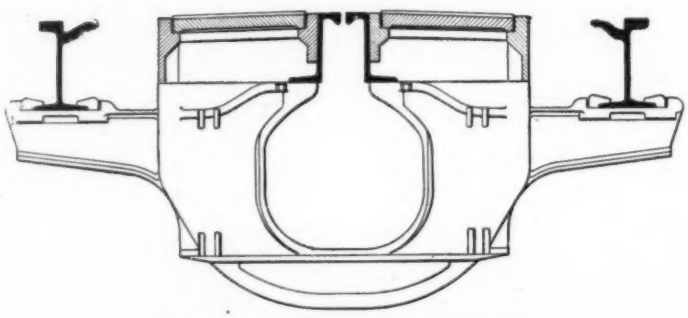


FIG. 4.—EXTENDED YOKE CONSTRUCTION, NEW YORK.

with a shank passing through the slot, and by two contact shoes in the conduit, which press against the conductors by means of springs.

The differences between the various methods of conduit construction are mostly mechanical, and the principal one is the position of the conduit with regard to the track rails. In London, Nice, Bordeaux, New York, and Washington, the conduit is formed in the centre of the tramway track, while in the other examples the conduit is formed under one of the track rails. The former is "centre slot" construction, and the latter "side slot" construction.

A cross section of a road built on the centre slot system is shown in Fig. 1, which illustrates the construction on the London County Council lines, and is typical. It will be seen that track rails of the ordinary girder type are used, and that the conduit is formed by a concrete tube about 24 in. deep. Cast iron yokes are placed at from 3 ft. 9 in. to 5 ft. apart, and are embedded in the concrete tube to form a support for the slot rails, which, as will be seen from the illustration, are of **Z**-section. The paving is of the ordinary type, and the track and slot rails are both tied to the yoke by means of tie bars, as shown.

The conductors are of **T**-section, and a detail is given in Fig. 2, which shows the actual dimensions of the conductor on the London County Council tramways. These conductors are of special mild steel, having a high electrical conductivity, and are carried from porcelain insulators, which, in turn, are bolted to the underside of the slot rails, as shown in Fig. 3, which is a cross section of the track at an insulator box. It will be noticed that the conduit is widened out to form the box, and that removable box covers are used for giving access to the insulators for cleaning or adjustment.

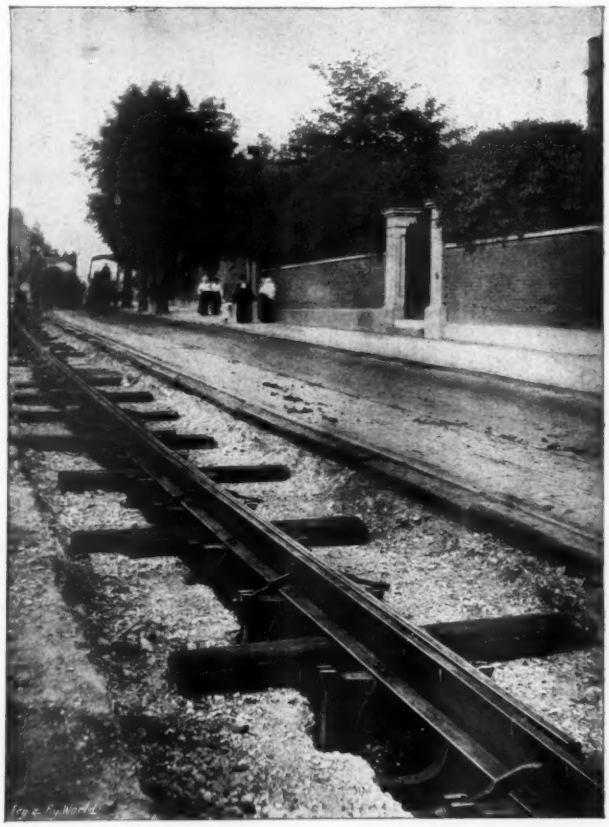


FIG. 5.—METHOD OF BUILDING UP CENTRE-SLOT CONDUIT, WITH ORDINARY YOKES.

On the London lines first constructed the track rails are carried directly upon a thick bed of concrete in an exactly

similar manner to the track rails for an overhead system, and are only connected to the slot rails or to the yokes by the tie bars before mentioned. In the other examples, however, of centre slot construction, viz., those in America, the track rails are carried upon an extension of the yoke, as shown in Fig. 4. It may here also be mentioned that in side slot construction one of the track rails is carried upon the yoke itself, while the other rests upon a concrete foundation in the ordinary way.

There is a considerable difference of opinion as to whether extended yokes are necessary. Mr. Connett states that the extended arms are so much waste metal, and it is certain that this type of construction costs some £900 per mile of single track more than the other. In building the lines there is not much gained either way, as, while the use of the extended yoke enables the whole track work to be clamped up together before any concreting is done, with the simple yokes the conduit can be built first, and the track rails laid after, which may be a convenience under certain circumstances. Fig. 5 shows the method of building up a centre slot conduit with ordinary yokes, the track rails being laid afterwards, and Fig. 6 the construction of a centre slot conduit with extended yokes, where the whole of the rail system is built up before the concreting is done.

Experience in London, however, has shown the great necessity of anchoring the track rails down, both at the joints and at intermediate points. While this may perhaps be easily done by means of special anchor plates at intervals, yet the fact that the extended yoke gives practically a continuous support and anchor is strongly in its favour. One of the great difficulties of renewing the track rail, under ordinary conditions, is to give the concrete time to set before allowing the car service to be re-started, and probably more trouble has been caused through this than any other. With extended yokes, however, the bearing of the rail is independent of the concrete, a less thickness of concrete is required, and the moment a rail is replaced and clamped up, traffic can be

FIG. 6.—CONSTRUCTION OF CENTRE-SLOT CONDUIT, WITH EXTENDED YOKES.

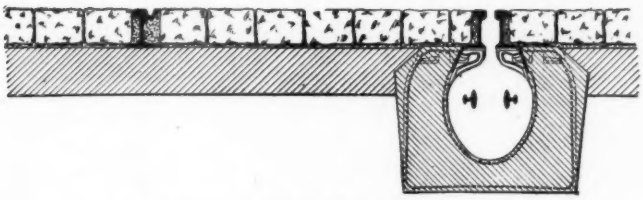


FIG. 7.—CROSS-SECTION OF A SIDE SLOT ROAD, BERLIN.

resumed without any danger. Sometime ago the writer suggested that if every third yoke were made with extended arms, it would, perhaps, meet the case. It is interesting to note that, on the more recently constructed London County Council lines, every other yoke has been made with extended arms, and although this has increased the cost of construction, it is believed that the maintenance account will benefit greatly thereby.

In the side slot system the two rails which form the slot are essentially of a different type both from the ordinary track rail and from the ordinary centre slot rail. Fig. 7 shows a cross section of a road in Berlin, built on the side slot system, and it will be seen that a bull headed girder rail, with special flange at the bottom, is used for each side of the slot, the outer rail to act as a track rail for the car wheel, and the inner rail merely to take the ordinary road traffic and to keep up the paving. There is no real reason why both rails

FIG. 8.—FEEDER PILLAR, L. C. C. TRAMWAYS. (FRONT VIEW).

FIG. 9.—FEEDER PILLAR, L. C. C. TRAMWAYS. (BACK VIEW).

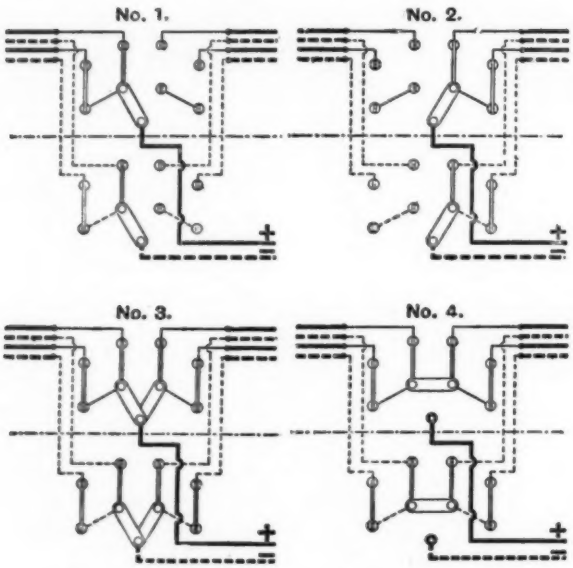


FIG. 10.—DIAGRAM OF SECTIONAL FEEDER SWITCHES, L. C. C. TRAMWAYS.

of the slot should be made of the same pattern, as the inner one could easily be of the same shape as the slot rail of the centre slot conduit; but, in practice, it is found advantageous only to have rails of two types in service.

While the side slot conduit system certainly gives a much better road appearance than the centre slot, and is somewhat cheaper in construction, yet it has several serious disadvantages in use. These are (1) a wider slot is necessary, because it has to form the path for the wheel flange, as well as for the plough, and on all curves this extra width may become rather serious on account of wear; (2) because of the extra width, and because the wheel flanges run in the slot, much more mud is thrown into the conduit than with the centre slot, which is usually kept about $\frac{3}{8}$ths of an inch higher than the ordinary track rail; (3) it is very difficult to design a point which can be used both as a track and a plough point.

This latter defect is perhaps the most serious one of all. It will readily be seen that with points of 100 ft. radius, such as are in frequent use, the length of the point is very considerable, and it is most difficult to support it at its outer end where it has practically nothing but the slot itself to rest upon. As the weight upon any wheel of an ordinary four wheeled truck may be in the neighbourhood of three tons, it will be seen how difficult the problem is.

To avoid this Mr. Connett, on the Paris and Bournemouth lines, diverted the side slot to the centre immediately before all special work, and he was thus able to use an independent point for the plough, and an ordinary point for the track. While excellent in mechanical results, this means that the special work for a side slot system costs just the same as for a centre slot system, and, as such special work is excessively costly, the trouble with a combined track and slot point must have been very great to have induced such a step.

The writer understands, however, that Mr. Connett has recently designed a new type of point, which can be used

both for the track and the slot, and that this point will shortly be put to a practical test at Bournemouth. It is to be hoped that it will be successful, as its use would mean a considerable reduction in the cost of side slot conduit construction.

On the early conduit lines the insulators which carry the conductor rails were supported from the bottom of the conduit, but on all modern lines they are suspended from the slot rails, as mentioned earlier and shown in Fig. 3. By this means the bottom of the conduit is kept clear of obstructions, and can thus be cleaned much easier, while the insulator itself is kept above the mud, &c., which always lies at the bottom of the conduit.

The amount of mud and debris which get into the conduit varies considerably, and depend to a very large extent upon the amount of ordinary traffic on the road. London seems to be specially troubled in this respect, and a large staff of men is employed every night in scraping the conduits clean. Some idea of the quantity of mud which collects may be obtained from the statement that during the last year over 3,000 tons were removed from the catch pits on about fifty miles of single track. The cost of this cleaning is considerable, and if some means could be devised to lessen the quantity of mud which gets into the conduit, it would be a good thing. The width of slot has a great deal to do with this, and, on the more recent lines, where a slot 1 in. wide has been adopted, there is no doubt that a greater quantity of mud will be encountered.

In New York a mechanical scraper is used, and a similar one has been tried in London. It was found, however, that mud accumulated in front of the scraper, and quickly choked it. Hand scrapers are now employed, and, where the mud is at all hard, water is used for flushing to

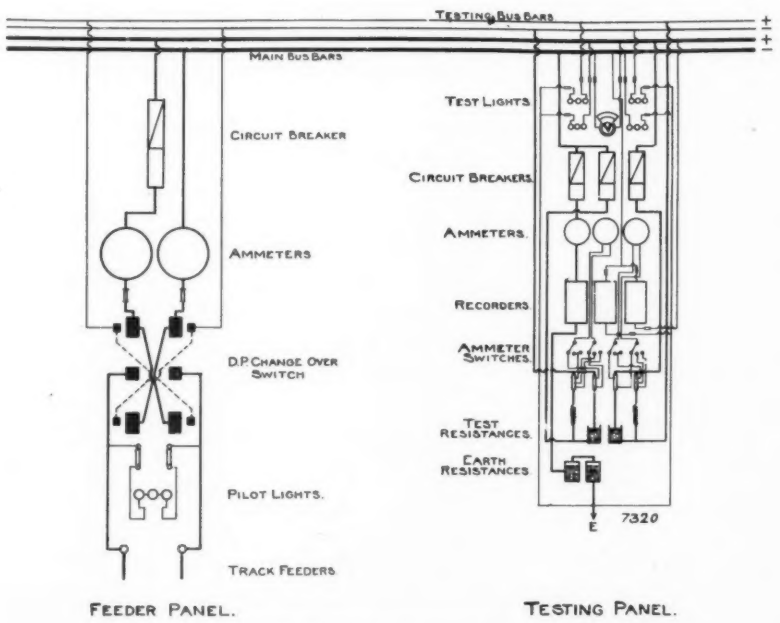


FIG. 11. - DIAGRAM OF STANDARD FEEDER AND TESTING PANELS, L. C. C. TRAMWAYS.

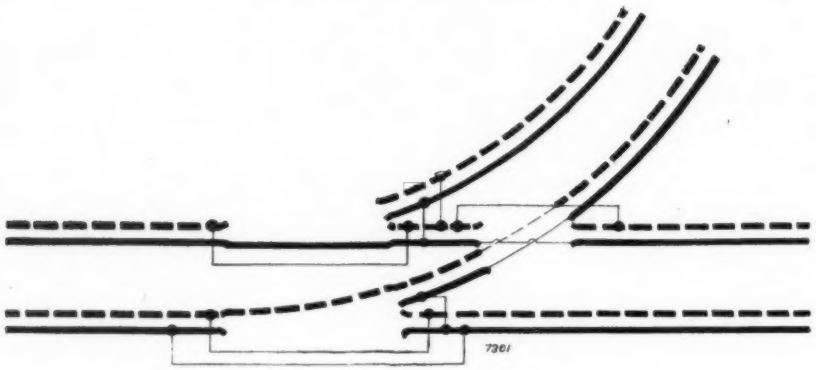


FIG. 12.—STANDARD ARRANGEMENT OF ORDINARY TRACK JUNCTION, L. C. C. TRAMWAYS.

soften it. This has the serious disadvantage of splashing the mud upon the insulators, with the result that they, in their turn, have to be frequently cleaned and inspected. Experiments are being made with a view of entirely dispensing with the water flushing, and it is hoped that the insulators will keep clean enough to warrant the doing away altogether with the present insulator box covers, which are now used. It has been found possible to do this both at Bournemouth and Paris, but the conditions of road traffic and mud are quite different in those towns from what they are in London.

The electrical arrangements of a conduit line are very similar to those for an overhead line, with the exception that, as there are two insulated conductors in the conduit, both positive and negative feeder cables have to be used. On the London tramways a separate pair of feeders is run from the sub-station to each feeding point, these being situated approximately half-a-mile apart. At the feeding point feeder pillars are erected for controlling the conductor rails in both conduits, and at the feeding points the conductor rails are separated by a distance of about 2 ft. in the straight line, so that the plough breaks contact in passing through from one section to the other.

Feeder pillars for conduit lines are essentially larger than those for overhead systems, as both positive and negative switches have to be used. In Fig. 8 is shown the front view of one of the London County Council feeder pillars, and in Fig. 9 the back view. It will be seen that there is a door at the back and another at the front, but these are provided with different locks, so that they cannot be opened incorrectly. The drivers of cars and the superintendents are allowed access to the switches themselves, so that they may cut off the faulty portions of the line, or telephone to the sub-stations, but access to the back can only be obtained by one of the electrical staff, for the purpose of altering any of the connections.

It will be seen from Fig. 9 that certain triangular links are provided, and their object is shown by the diagram in Fig. 10, which gives the four possible combinations which can be obtained. Usually the track is fed only in one direction at each feeding point. No. 1 shows the left hand tracks being fed, and No. 2 the right hand tracks; the necessary changes having been made in the position of the feeder links at the back of the pillar. It will be seen that nothing happens even if the switches of the other tracks in the same pillar are accidentally closed. In the third example, the links are so arranged that the tracks in both directions are being fed, while the fourth example shows the feeder disconnected, and the two sets of tracks joined through.

It has been remarked earlier in this article that both conductors in the conduit are insulated, and that the track rails are not in any way used as part of the circuit. On the London County Council system, however, the negative bus-bar in the sub-station is connected to earth, and the negative conductor rail throughout the system is, therefore, at earth potential. Should a fault occur on the positive conductor rail in the nature of an earth, it, of course, causes a short circuit, and the circuit breaker controlling that section opens. Means are provided in the sub-station for showing the nature of the fault outside, and if it is shown to be *positive* earth the polarity on that section is reversed by means of change-over switches, so as to bring the positive earth on to the negative side. By this means the system can be kept going until it is convenient to send out to locate the fault. Should an earth occur on the *negative* conductor rail no harm results, except that a part of the return current would go back through the earth. When this occurs a resistance is inserted in the earth connection at the sub-station, so as to keep the value of the earth current as low as possible.

In Fig. 11 is shown a diagram of a standard feeder panel, with the reversing switches, and of a standard testing panel, by means of which the nature of the fault on the track is ascertained. In addition to the tests which are taken when a fault occurs, daily tests are made of the insulation of the conductors in the conduit by means of low reading ammeters. A recent test selected from an average dry day gives a leakage of only 2·8 ampères for the whole fifty-two miles of single track on the positive conductor, and of 7·3 ampères on the negative conductor. This is an exceedingly good result, and one which is not in any way inferior to an overhead system.

The breaks in the conductor bars at the half mile feeding points have already been mentioned, but there are additional breaks at all special work, where the two conduits connect with one another. In some places the rails are separated by at least 12 ft. in a straight line, and the car has to coast for that distance, while the lights of the car are extinguished at night. In Fig. 12 is shown a diagram of the standard arrangement at an ordinary track junction, from which the breaks can be seen, with the connecting cables which have to be run round to connect the bars through.

Many people have tried to design an arrangement whereby the cars should not lose current at the breaks in the conductor bars, and the large majority of the suggestions which have been received are for the use of two ploughs on the car, one at the front end, and one at the rear end; the idea being that the forward plough shall make connection before the rear plough breaks it. Putting on one side the trouble of having two ploughs to attend to instead of one, and the difficulty there would be of finding room under the car for such a duplicating arrangement, it seems to be either forgotten or not known that the various sections of the line are frequently reversed in polarity in order to

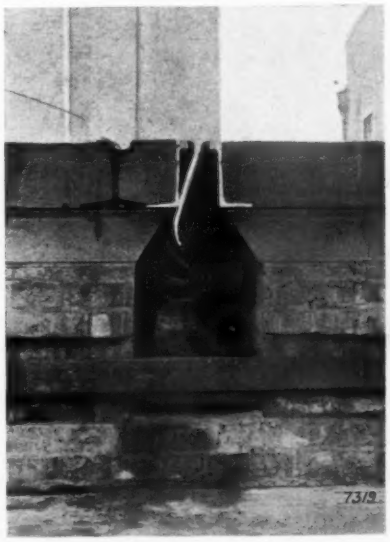


FIG 13.—VIEW LOOKING INTO THE CONDUIT FROM A TRAVERSER PIT IN A CAR SHED.

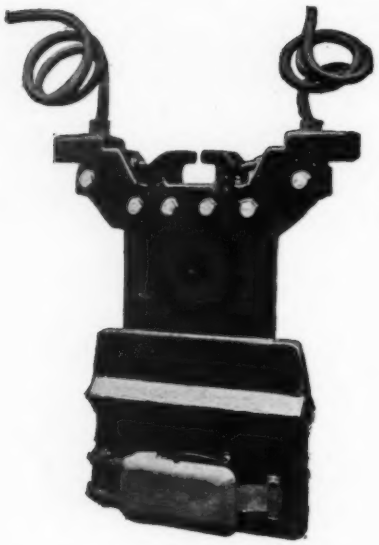


FIG 14.—TYPE OF PLOUGH USED AT BOURNEMOUTH AND PARIS.

FIG. 15.—NEW PATTERN PLOUGH, L. C. C. TRAMWAYS.

keep all faults on the negative side. In passing through the sections two ploughs would, of course, make a dead short circuit should it happen that one of the sections had its polarity reversed with regard to the other.

At all breaks in the conductor bars the ends of the bars are flared outwards so as to provide an easy passage for the plough. In Fig. 13 is shown a view looking into the conduit from a traverser pit in a car shed. The conduit in this instance has been diverted to the side of the track in order that when the cars are in the sheds over the pits, more access can be obtained to the motors. The **Z** slot rails and the conductor bars can be easily seen, together with the flare on the bars at the ends just mentioned.

Perhaps the most important part of the car equipment for a conduit line is the plough. On the Continent these ploughs are generally of very flimsy construction, and are provided with flappers which make connection with the top of the conductor bars, and collapse when the plough is lifted through the slot. In Paris and Bournemouth, however, a mucn more mechanical type of plough is used, and a view is shown in Fig. 14 of this. The early ploughs used on the London County Council lines were identical with this construction. The body of the plough was made of wood, and the whole plough was dipped into an insulating compound in order to keep moisture out. Painful experience, however, has led to the discarding of this plough in London, although it seems to be very successful in the two towns just mentioned. The London ploughs are now made of Dermatine, which is a kind of rubber, and the whole of the lower part of the plough is moulded of one solid piece, with the electrical connections embedded. The shank of the plough, or that part which passes through the slot, is made of steel plates, which can be renewed when worn, and the two conductors pass up between these steel plates. This type of plough has proved most successful in practice. It does not require any treatment with

insulating compound, and it can be washed down by a hose when dirty. This plough is shown in Fig. 15, and it will be noticed that a kind of hood is provided over the collecting shoes, which aids very considerably in keeping dirt and moisture from getting on to them.

The type of plough used in New York is illustrated in Fig. 16, and it is of a much more flimsy construction than would be considered satisfactory here. The lower part is made of wood, and no insulating compound is used. This figure also generally illustrates the plough used in Washington.

The ploughs are carried underneath the cars at a suitable height by means of carriers which vary considerably in different countries. In Paris, Bournemouth and London the carriers consist of channel or **Z** irons on which the head of the plough rests, and on which it can slide backwards and forwards, if necessary, across the full width of the car. Such a carrier for a bogie truck car is shown in Fig. 17. The wide travel provided by this type of carrier has many advantages. It enables the conduit to be placed either centrally or under the running rails, and in the event of a plough taking a different track from the car, at a junction, it simply travels along the carrier until it falls off into the roadway. No damage is, therefore, done except to delay the car for a short time until the plough can be replaced. From Fig. 16, however, it will be seen that the American plough is carried from two cross rods. These are very short, and only allow the plough a very limited side movement. In the event of such an accident just mentioned, the plough would become jambed, and serious delay would result. In the writer's opinion the type of plough now used in London, which is the outcome of much costly and troublesome experiment, is, perhaps, as perfect as can be designed.

To be able to remove or replace a plough on the roadway, plough hatches are formed at each half mile section, and immediately in front of all special work. These hatches consist of removable sections of the slot rail, which, when taken out, expose the whole conduit, and allow the plough to be got at. Hatches are provided in the floor of the car immediately over the plough in addition. To remove the plough from a car in a car shed the car is run over a pit, either where the conductor bars are removed,

FIG. 16.—TYPE OF PLOUGH USED IN NEW YORK.

or, as in the case of the London tramways, where the conduit is diverted to the side. In this case a special open type of conduit is employed in the car pits, which gives full access to the plough at any time.

Perhaps the most costly part of conduit tramway construction is the special work, *i.e.*, points, crossings, &c., at any rate so far as the centre slot system is concerned. Special work, therefore, is

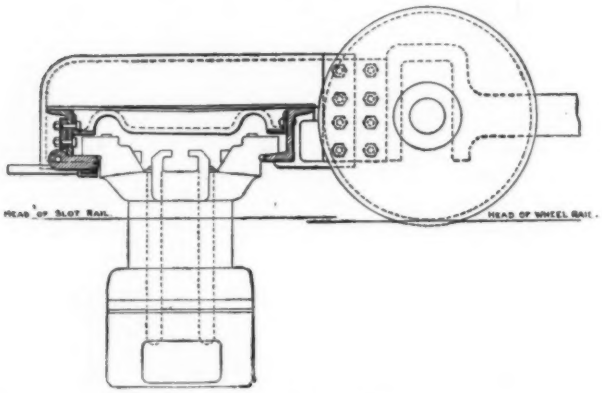


FIG. 17.—CARRIER FOR BOGIE TRUCK CAR.

avoided wherever possible, and, until recently, expensive street widenings have often been undertaken to provide a through double track rather than go to the expense of putting down the special work necessary for a short length of single line, which might afterwards have to be removed should the street widening take place at a later date. An interesting example of the use of a single line without any special work for the conduit may be seen in London Street, Greenwich, where, although two tracks converge into one for a short distance, the two conduits have been continued independently in the centre of the pair of track rails. Ordinary track rails are used, and no points whatever are used for the conduit.

A development of this idea has recently been got out by Mr. A. L. C. Fell and the writer, whereby not only are all points done away with on both the track and slot rails, but the two conduits can be laid down at once in their permanent positions ready for a double track, should the road afterwards be widened. This has been accomplished by the combined use of interlacing tracks, and of conduits constructed in such a way that the slot rails may be used as running or track rails.

Fig. 18 shows one application of this method. The inside track rails of the double track are interlaced, while the outside track rails run into the slot rails of their own conduits. In this example the two conduits and their slot rails are kept to the outside, with the two interlaced track rails inside. The ploughs of the cars, therefore, move to the side in passing, and, in the event of a double track being constructed at any future time, the existing conduits would be in their correct positions as centre slot conduits, and only new track rails would be necessary. There are no moving points required either in the track or

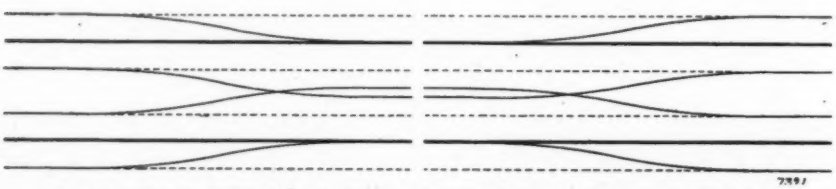


FIG. 18.—EXAMPLE OF INTERLACING TRACKS AND OF CONDUITS CONSTRUCTED IN SUCH A WAY THAT THE SLOT RAILS MAY BE USED AS RUNNING RAILS.

slot rails, and the conductor bars in the two conduits are kept continuous throughout.

The only thing which militates against the more extended use of the conduit system is its prime cost. To build a conduit line on satisfactory engineering principles costs from £13,000 to £16,000 per mile of single track, independent of any feeder cables. A large proportion of the cost is required for the removal of sub-surface obstructions, and, in those cities where the use of a conduit is warranted, it is generally found that the greatest complication of underground pipes, &c., exists. A good deal of the cost could be obviated if it were possible to construct a conduit at a shallower depth than at present. Unfortunately, however, anything less than 24 in. in depth gives considerable trouble on account of the rapid accumulation of mud, &c. The conductor bars are generally suspended at about 14 in. from the road surface, and any depth below them is merely to form a receptacle for dirt, so that the conductors shall be kept clear. Some people seem to imagine that a shallow conduit must necessarily collect less mud than a deep one, entirely forgetting that the amount of mud which gets into a conduit depends only upon the width of the slot. A shallow conduit simply means that the cleaning has to be done much more frequently, and that the risk of the conductors getting earthed is very much increased.

(The writer is indebted to Messrs. Whittaker & Co. for permission to use Figs. 1 to 7, and Figs. 10, 14, and 17.)

BOOK REVIEW.

Gas Engine Design. By C. E. Lucke, Ph. D. (London: Constable & Co., 1905. 254 pp., 145 illustrations. 12*s.* 6*d.* net).

The author of the above work is an American professor, and the book is one of many signs that Americans are beginning to take a deeper interest in gas engines than was formerly the case. Until a few years ago there was only one American firm manufacturing large gas engines; now there are several either manufacturing or experimenting with a view to manufacturing, and it is interesting to note that in most cases the original designs for these engines came either from England or the Continent.

In this book the author has not attempted any explanation of the thermodynamics of the gas engine, or descriptions of the properties of fuels, lubricating oils and the like, but has confined himself to a consideration of the gas engine as a piece of machinery; or as he himself puts it, he considers it "quantitatively."

The book is in three parts. Part I. treats of Power, Efficiency and Economy, and illustrates the effect of varying conditions on the mechanical and thermal efficiencies. The author uses a standard air-card for purposes of comparison with the actual indicator card and determines the diagram factors for the various types of engines and fuels. Methods of estimating the mean effective pressures which result from the use of different fuels are given and curves of efficiency for several engines are inserted.

In Part II. we have a long discussion, extending over eighty-six pages, of the forces due to gas pressure and inertia, including a fairly full treatment of the question of the mechanical balance of the engine parts. In Part III. the author discusses the dimensions of the different engine parts at great length. Indeed, the discussion of the various formulæ given in this book seems to us to be needlessly prolonged. For instance, the author gives twenty different formulæ for the thickness of the cylinder barrel, extending over eight pages. There are twenty pages on the design of valves (all of the simple mushroom type) and thirteen pages on cams. The author thinks that the valve opening ought to be proportional to the piston speed at each point in the stroke so as to maintain a constant gas velocity through the valve opening. Most designers will disagree with him here, and hold that having decided on as low a mean gas velocity as is consistent with a good commercial design, it is better to open the valve to the full amount as quickly as practicable and close it again as quickly as practicable, keeping it open the maximum amount for the maximum length of time, and thus reducing the suction or back pressure. The formulæ given by the author might with advantage be summarised into tabular form for convenience in reference. The book is excellently illustrated and contains a large amount of useful data covering engines varying from the small automobile engine to the large stationary engines. Some sectional drawings of breech ends and other details would add considerably to the value of the work.

Surface Contact Traction.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E.

NUMEROUS methods have been proposed for the supply of current to electric tramways by means of surface contacts. All such methods are similar in the respect that underground conductors are laid in closed conduits with distribution boxes at certain intervals, from which current can be delivered through metal contacts, placed at distances of a few feet apart between the rails of each track, matters being arranged so that each separate contact can be electrically charged and can deliver current only when the vehicle is immediately above the contact.

In many of the surface contact systems proposed, undesirable features have been found. An almost universal objection is that the contacts project so far above the paving level as to constitute a source of danger to horses, cyclists, and foot passengers.

The reason for this undesirable projection appears to be the not insuperable difficulty of devising a collector to make contact with a plate of which the upper surface is at road level. Further, owing to the heavy pressure exerted by the collector upon the contact plates, much current is sometimes wasted in overcoming the friction developed, and the friction causes rapid wear of the parts in question, involving frequent renewals, and so adding largely to the cost of maintenance.

Another weak point of common occurrence is that the materials supporting and insulating the contact plates or boxes are such as no competent road engineer would consider adequate for withstanding the strains due to heavy traffic. Consequently, some systems have been condemned because experience has shown them to be incompatible with efficient and economical maintenance of the paving.

The foregoing are some of the external mechanical troubles which have proved stumbling blocks to most inventors of surface contact systems. There are, however, other difficulties connected with the electrical part of the equipment, and the non-success of many ingenious systems must be directly attributed to the complicated or inadequate manner in which such difficulties have been dealt with.

One general class of design is that in which the switch mechanism is operated by electro-magnets, one placed in a switch-box serving each contact or by a larger magnet operating a compound switch placed in a distribution box and serving a number of contacts.

The objection to either arrangement is that more or less complicated and delicate apparatus of the kind is clearly operated under unfavourable conditions when situated in damp and imperfectly-ventilated boxes or chambers below the street level. Attempts made to eliminate the troubles due to moisture by the use of mercury switches, have not proved satisfactory, and the general practice is now to use watertight boxes.

Speaking generally, it may be fairly said that electro-magnetic devices in underground boxes and chambers are not conducive to uniformly reliable results, and in systems where the various sections of the line are controlled by multiple electro-magnetic switches, numerous wires and connections below the surface are necessary for the purpose of connecting the switches with the various contact plates, thereby involving additional expenditure and adding to the risk of failure.

Moreover, in several systems of this

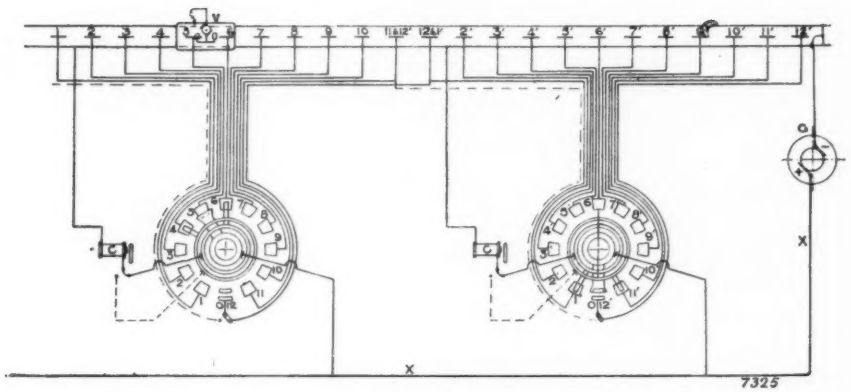


FIG. 1.—DIAGRAM ILLUSTRATING THE METHOD OF TRANSMITTING CURRENT FROM THE GENERATORS TO THE MOTORS. "CLARET-VUILLEUMIER" SYSTEM.

class it is necessary to employ a double row of contacts for each track and two collectors for each car, thus doubling the number of obstructions to ordinary traffic, increasing the cost of installation, maintenance, and car equipment, and giving rise to difficulty in turning sharp curves with the two collectors.

As an example of surface contact traction operated by the aid of underground electro-magnetic switches, we may cite the tramway running from the Place de la Republique in Paris to the suburb of Romainville outside the fortifications. This line was equipped in accordance with the "Claret-Vuilleumier" system, and the fact that it has been in operation since June, 1896, is a sufficient proof that the difficulties attaching to the type of design adopted do not necessarily interfere with the attainment of practical success. The length of line

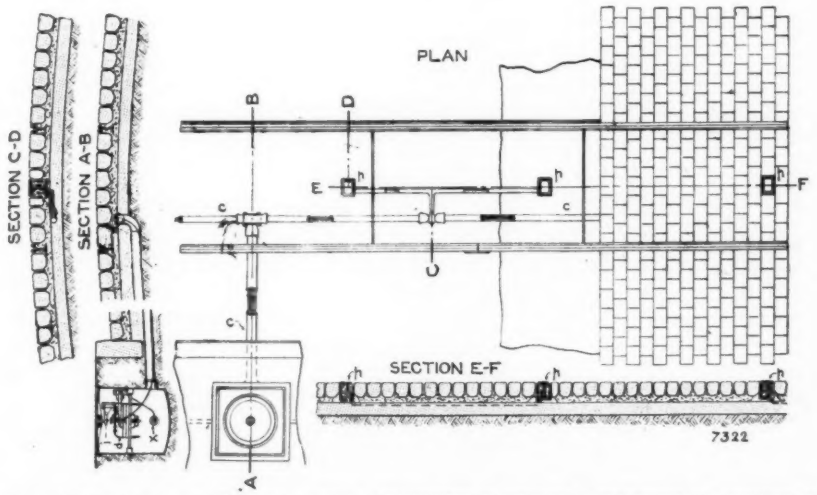
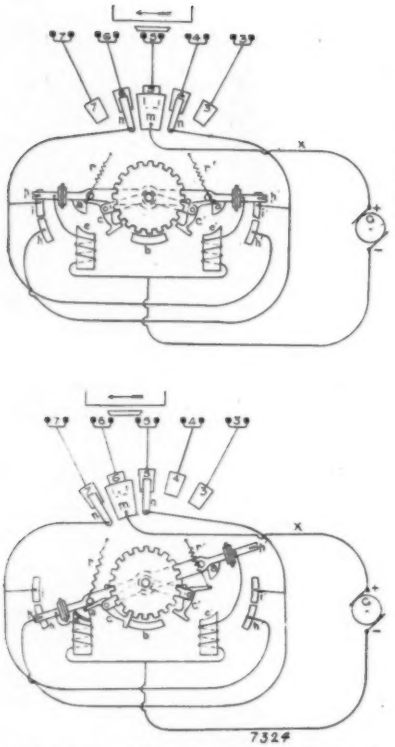


FIG. 2.—"CLARET-VUILLEUMIER" SYSTEM. GENERAL ARRANGEMENT OF CONTACTS, DISTRIBUTORS AND CONNECTIONS.



FIGS. 3 AND 4.—DIAGRAMS SHOWING OPERATION OF DISTRIBUTOR. "CLARET-VUILLEUMIER" SYSTEM.

inside the city boundary is 2½ miles with a double track, and outside the boundary nearly 2 miles, this section having a single track with loops at intervals for the passage of cars. From the city terminus there is a rising gradient as far as the fortifications, the most severe gradient being about 1 in 16 for a length of 700 yards. Beyond the gates the route is practically level.

The parts of the installation with which we are particularly concerned are the contact plates, and the means employed for the supply of electricity to these contacts during the passage of the cars.

Fig. 1 is a diagram illustrating the method of transmitting current from the generators to the motors carried by the cars.

From the dynamo *G* the current is conveyed by an underground conductor *X* to distributors situated at intervals of 300 ft. along the route. Wires are carried from each distributor to the right and left, as shown in the diagram, and connected with an element of each contact placed between the running rails. The contacts consist of steel blocks connected in pairs and situated at a distance of about 8 ft. 3 in. one from another. It is from this succession of elements, which, by the automatic action of the distributors described hereafter, are energised during the passage of a car, that the motors derive current by the aid of a suitable collector. The collector is disposed so that it shall always be in communication with the live contact immediately below the car. As the car advances the

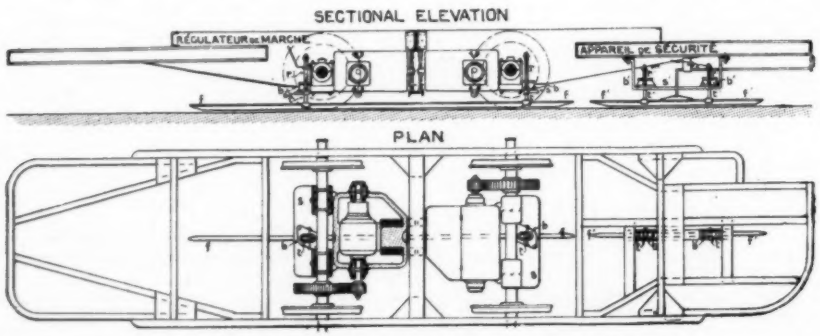


FIG. 5.—DETAILS OF SAFETY SKATES. "CLARET-VUILLEUMIER SYSTEM.

collector touches the succeeding contact before having quitted the preceding block. As the front contact is connected to the distributor by one of the wires, a small flow of current returns to the distributor and acts upon an electro-magnet which places the contact in direct communication with the main conductor by means of the switch. At the same moment, the connection of the rear contact is broken, and the front contact continues the supply of current until it is replaced in turn by the next contact in advance. The return current to the dynamo *C* passes through the ironwork and wheels of the car and along the running rails. The rails are bonded to insure electrical connection throughout, and special forms of rail are employed at points and crossings, the rails being insulated one from the other by vulcanite and laid in such manner as to form a rigid framework capable of withstanding heavy traffic.

Fig. 2 contains a plan and three sections illustrating the general arrangement of the contacts, distributors, and connections. The contact blocks *p* have the same top and bottom dimensions and the same height as the stone sets or wood blocks adopted for ordinary paving. They are insulated with bitumen, which also fills in the spaces between the top and bottom flanges. To each of them is connected a copper wire by which they are coupled in pairs and placed in communication with the distributor.

The service wires, with rubber insulation and of three millimetres diameter, are run in cast-iron pipes *c* situated below the track and having between each pair of contacts a junction-box through which a wire is taken to the wire coupling the two blocks.

Opposite each distributor a junction-box and branch-pipe *c'* serve for the connection of the longitudinal wires with the switch.

The distribution-boxes are placed immediately below the level of the foot-pavement, see section *A B*. The boxes are of cast-iron and are made in two sizes, for the reception of one or two distributors according as the track is single or double. A single distribution-box is shown in plan and section in Fig. 2. It is closed by a cover of about 1 ft. 7 in. diameter, so that a distributor can readily be introduced or removed through the opening. An air-tight joint is made by means of an india-rubber ring, the cover being secured at the centre by a screw passing into a strong lever *i* pivoted upon an axis connected with the wall of the box, this lever serving also to make or break the connection of the distributor *d* with the main cable *X*.

The distributor is really a compound switch with twenty or any smaller number of contacts mounted upon a metallic disc in such a way as to insure perfect insulation. The disc is supported by a cross-bar, as shown in section *A B*, Fig. 2, and upon the vertical axis, in the same drawing, are placed (1) a disc having as many gaps as there are contacts in the apparatus; (2) three plates resting upon three consecutive contacts; (3) three discs intended to maintain electrical communication between the three plates and three fixed connectors. The middle plate distributes the current received from the main cable, *X*, and each of the two other plates communicates, through a commutator, with one pole of an electro-magnet, the other pole of which is connected with the rails of the track.

The operation of the distributor will become clear by reference to Figs. 3 and 4. In Fig. 3 a car is in the act of collecting current from contact No. 5. As the car moves in the direction of the arrow, the collector establishes a bridge between the plates, *m* and *n*, thereby exciting the magnet, *e*. Consequently the armature, *a*, moves in the direction of the magnet, causing the ratchet, *g*, to engage with the central toothed wheel, and moving the rotatory system through one-twentieth of a revolution to the position shown in Fig. 4. The three plates, *m*, *n*, *n'*, are moved forward one switch contact, and the car is fed by the pavement contact No. 6. At the same moment the ratchet is arrested by the

stop, *b*, the oscillation of the armature and the rotation of the three plates being definitely determined.

This condition is maintained until the car has cleared contact No. 5, when the ratchet is repelled by magnetic action restoring the commutator and armature to the normal position indicated in Fig. 3.

The collector on the car is formed by a bar of angle-iron having a length of 10 ft., so that continuous communication with one or other of the contact blocks shall always be maintained. Fig. 5 gives a sectional plan and longitudinal section of the underframe of a car in which the general arrangement of the equipment is made clear. The collector, *f*, is held in position by two vertical suspension rods, *t*, which slide in the collars, *b*, mounted upon the supports, *s*. The openings through which the vertical rods pass are formed so that a certain freedom of movement is permitted to the collector, and at the upper part of each suspender a cross-bar is fixed, at the extremities of which are springs, *r*. Owing to this arrangement, the collector is free to follow all sinnosities of the track, and has been found to answer its purpose in a satisfactory manner in all conditions of the road surface, and in spite of mud, dust, and snow.

For the purpose of guarding against the possibility of any stud remaining alive after the passing of a car, the safety skate shown in Fig. 5 is fitted behind the collector. This device has the effect of blowing the fuse if by any chance the circuit breaker should fail to operate.

While the "Claret-Vuilleumier" system is not free from complications in connection with the automatic switching arrangements, and the wiring between the switches and the contact plates, it is evident from the foregoing description that all the details have been carefully thought out, and that the system deserves to be regarded as a practical and workable solution of the difficulties presented by the method of traction which it exemplifies.

As a matter of fact, the official reports of engineers connected with the Service du Control des Tramways show that the number of interruptions to the service from all causes on the Paris-Romainville line does not exceed the proportion of 1 in 2,000 car-miles. This record is a sufficiently satisfactory answer to the criticism that the delicacy of the distributing mechanism constitutes a fruitful cause of breakdown.

Apart from the general objection to the employment of electro-magnetic apparatus in boxes placed below pavement level, the chief disadvantages of the system are: The multiplication of conduits and service wires, the impossibility of working two cars on any one section of the line, and the projection of the contact blocks above the general level of the street paving. It is true that the sections may be reduced in length to any desired extent by increasing the number of distributors, but this involves increased outlay and maintenance charges, and adds to the number of pavement covers, which are always undesirable from the standpoint of the foot-passenger. The projection of the contact-blocks, as we have already mentioned, is a disadvantage shared by most other systems of surface contact, although far less than that due to the third rail of the open conduit, or the posts and overhead equipment of the trolley system.

A second general class of design is that in which electro-magnets are carried in the under-frame of each tramway-car, and each pavement contact contains, or is connected with, a simple switch operated as the car passes along the track.

Systems developed in accordance with these conditions avoid the difficulty connected with the use of underground electro-magnets, and permit the simplification of the switch to such an extent that only one moving part is required. Owing to its simplicity the switch can be adequately protected from moisture by enclosing it in a hermetically-sealed box or other receptacle. Economy of cable, and the small number of joints required are other advantageous

features of the systems included in this category, and an important point is that a minimum disturbance of the paving is necessary for the installation and maintenance of the contacts, switches, and conductors.

For the purpose of operating the switch contained in, or connected with each surface contact block, it is necessary to magnetise either the collecting skate or bars of metal placed on each side of it, so as to form poles of the magnet system. The application of electro-magnets and accumulators for exciting the magnets when the car is at a standstill, involves a very considerable increase of the dead weight to be moved. In systems of this class the weight of the car equipment usually varies from about one ton up to two tons, or from ten to twenty times the weight carried by a car operated on the trolley system. Consequently, on a tramway line where one hundred cars are employed, nearly 90 tons of useless dead weight are continually transported during working hours, and it is easy to understand that this means an appreciable increase in the consumption of current. Further, magnetised bars attract the particles of iron or steel removed by friction from the surface of the contact blocks, as well as other pieces of metal such as nails and horse shoes that may be accidentally dropped in the roadway. A fringe of metallic particles along the edge of the magnetised bars, and the occasional addition of pieces of scrap-iron are undesirable adornments, and if the latter project downwards to a sufficient extent, there is serious risk of earthing or short-circuiting at turn-outs and crossings. Such *contretemps* are by no means unknown, and when they occur the coils of the electro-magnets are not infrequently burnt out, necessitating removal and re-winding.

To avoid such risks, turn-outs and crossings are usually insulated, as in the class of surface contact systems mentioned above. In some cases the amount of current required for magnet excitation is a small item, but in others it represents an excess of fully 20 per cent. over the consumption for an equivalent traffic conducted by means of overhead trolleys. A still more serious loss occurs when the collector forms an integral part of the car magnet, as friction is then supplemented by the drag due to magnetic attraction.

A matter requiring careful attention in the installation of car magnets is to guard against the sagging of the collector owing to the weight of the magnets. Neglect of this point leads to heavy wear of the surface contact plates, as well as to grooving of the permanent way between the contacts. Grooves have been cut in this way to a depth of an inch on more than one system of surface contact tramways.

The contacts employed in connection with car magnets sometimes consist of a box containing the magnetic switch, and to insure a water-tight joint, the under surface of the lid is machined and fitted with considerable care. This is not a desirable type of design, because the upper side of the lid forms the wearing surface of the contact, and the cost of renewals is unnecessarily increased by the machine and fitting work. When essential portions of the

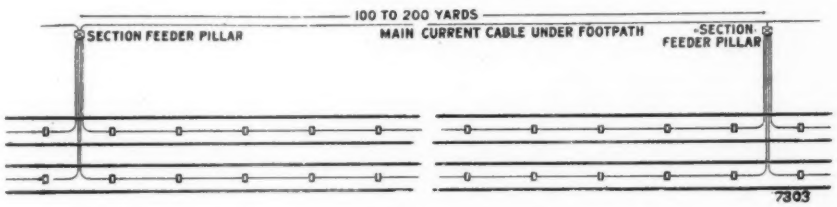


FIG. 6.—DIAGRAM OF CONNECTIONS BETWEEN CONTACT BOXES AND MAIN CURRENT CABLE. "LORAIN" SYSTEM.

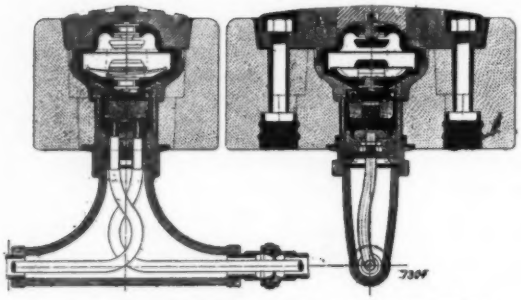


FIG. 7.—LONGITUDINAL AND TRANSVERSE SECTIONS OF CONTACT BOX. "LORAIN" SYSTEM.

switch are attached to the under side of the lid the objection is further increased.

Other forms of contact are practically solid, and the switch is fitted into a slot or in some simple manner that does not entail expensive work. Consequently renewals can be made more expeditiously and at less cost.

The objections raised against automatic electro-magnetic inter-connecting switches in distributing boxes apply in smaller measure to magnetic switches of all kinds, and it is impossible to ignore the possibility that the contact block may become permanently magnetised under the frequently-repeated influence of the car magnets. If this condition should obtain, the tendency will be for the switch to be retained in the "on" position, thereby keeping the surface contact block alive. To avoid any such risk some patentees make their contacts of special non-magnetic steel, but no variety of steel has been found that will permanently resist a strong electro-magnetic influence. That the moving parts of a switch are actually affected in the manner suggested seems to be shown by the fact that contacts found alive when they ought to be dead, can sometimes be disconnected by a sudden blow which breaks contact by shaking down the armature attracted to the upper portion of the contact box.

Electro-magnetic switches enclosed in box contacts generally consist of two carbon blocks of cylindrical form, one fixed and permanently connected by flexible cable with the main conductor, the other attached to a sliding or hinged piece operated by magnetic attraction. Admitting the reliability of this mode of making contact, it cannot be denied that the current can scarcely be prevented from making an arc as one carbon approaches or recedes from the other. In consequence, the carbon is slowly disintegrated, and the particles form a film which may eventually serve to convey a continuous leakage of

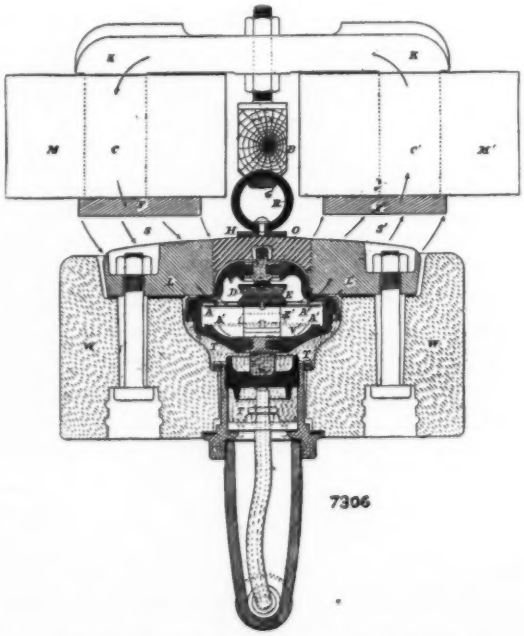


FIG. 8.—DETAILS OF CONTACT BOX. "LORAIN" SYSTEM.

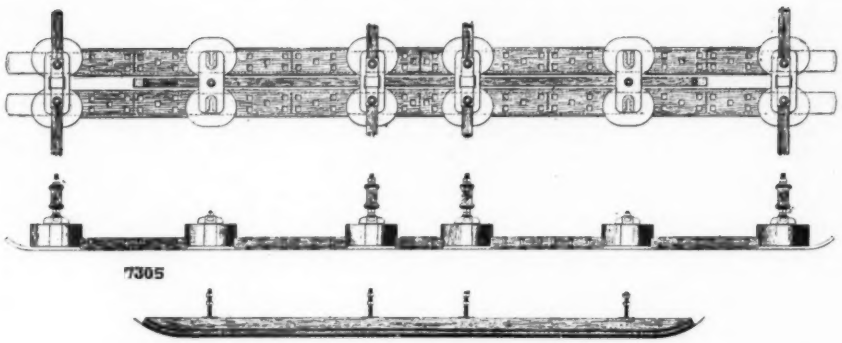


FIG. 9.—PLAN AND SECTIONAL ELEVATION OF MAGNETS AND SHOE. "LORAIN" SYSTEM.

current from the main cable to the surface contact. A trouble occasioned by the use of imperfectly insulated contact boxes is that current is able to leak across the sides of the box independently of the dead element of the switch.

The foregoing are some of the difficulties to be encountered, and the disadvantages to be minimised in applying the second general method of surface contact traction. That they have been overcome to a very large extent is evidenced by the fact that at the present time various reliable systems are available which are superior to trolley systems in point of safety and the public convenience, and are not inferior to open conduit systems in respect of efficiency and general safety, while involving far less capital expenditure and lower maintenance charges.

As examples of surface contact traction operated by the intermediation of car magnets we take three well-known systems, the first two employing hollow contact boxes enclosing the electromagnetic switches, and the third a solid contact carrying the same kind of switch in the lower end of a stem projecting downwards from the contact plate.

The first system to which we refer is of American origin, and is being

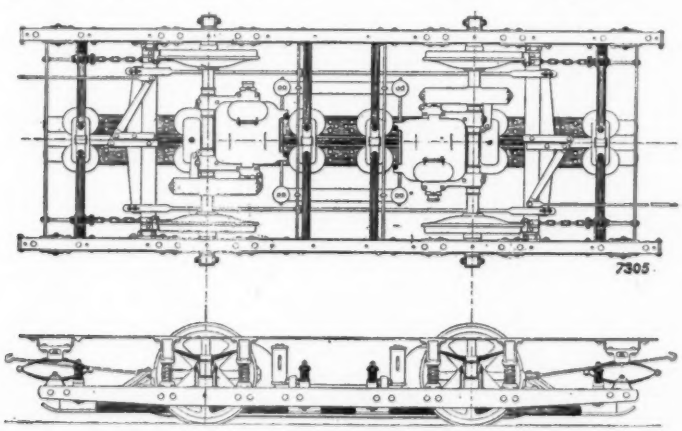


FIG. 10.—PLAN AND ELEVATION OF MOTOR TRUCK EQUIPPED WITH MAGNET AND CURRENT COLLECTOR. "LORAIN" SYSTEM.

exploited in this country by the London branch of the Lorain Steel Company, of Philadelphia. Considerable interest attaches to the "Lorain" system of surface contact traction owing to the fact that it was adopted some three years ago by the Wolverhampton Corporation, by whom its operation has been found sufficiently satisfactory to justify the equipment of various new routes upon the same principle.

The importance of the Wolverhampton installation is increased by the fact that there is not a yard of track on the "Lorain" system in operation anywhere else in the world. Initial trials were made on a short experimental line in Washington, but apparently without inducing American tramway companies to adopt the system.

Fig. 6 is a diagram of the connections between the contact boxes and the main cable, by which it will be seen that the wires are taken from the section feeder pillars, placed at intervals of from 100 to 200 yards, and thence underground to the centre of each track. The contacts are fixed 10 ft. apart at Wolverhampton, but this distance could be increased to 16 ft. if bogie cars were used instead of single truck cars.

The chief features of the system are the contact boxes and the car magnets. Figs. 7 and 8 are longitudinal and transverse sections of a contact box, which consists of two main parts, (1) the insulating material *W W* usually made of artificial stone described as "reconstructed" granite, and (2) the metallic cover *L O L'*, fitting into a recess at the top of the base. The cover measures 15 in. long by $9\frac{3}{4}$ in. wide, and is held in place by two bolts. At its highest point the cover projects about $\frac{3}{4}$ in. above the general paving level. The base contains a conical opening in the lower part of which is a brass cylinder, and to this is attached the junction piece affording accommodation for the service cables. The base also serves to support the bottom disc in which are clamped the lead casing of the cables, and carries the top terminal disc to which the conductor of the cables is secured by screws.

In the upper portion of the conical opening is an insulating cup in two parts *V* and *V'*, capable of being hermetically sealed by means of a gasket and annular screw ring. Brass terminals are moulded into the top and bottom sections of the cup, the upper terminal being screwed into the under side of the metal cover of the contact box, and serving to support the cup. The lower terminal connects the inside of the cup to the cable terminal by means of spring contacts clamping a tongue on the terminal disc.

Inside the cup is the circuit closer. A carbon contact *D* is fixed to the top of the cup, and a second contact *E* of the same material is attached to a soft iron plate, which is the armature to be acted upon by the car magnet. In its normal position the armature rests upon a circular ledge in the interior of the cup, as indicated by *A'*, and is connected with the lower brass terminal of the cup by a thin strip of hard rolled copper as illustrated in Fig. 7. This strip serves to make electrical connection with the moving armature, and acts as a guide to the armature in its vertical movement. The contact box cover is composed of three parts: two iron sections *L L'* cast to a central piece *O*, of non-magnetic steel of hard quality so as to resist the wear of the collector shoe *H*. The space *T T T* within the contact block is filled with oil intended to prevent moisture leaks from the cable terminal.

After the system had been in operation for some months at Wolverhampton, it was found desirable to make an improvement in the construction of the contact box covers, which are now somewhat wider and fitted with a removable wearing plate. This alteration has had the effect of protecting the artificial stone base from the destructive effect of heavy traffic, and of avoiding the necessity of changing the expensively-fitted switch covers owing to wear of the upper surface. Although adding slightly to the area of roadway

occupied and increasing the cost of construction, the changes to which we refer have certainly removed two previously existing defects.

Reference to Fig. 8 will show that the path of the magnetic lines due to the excitation of the magnets *M M'* passes from the keeper *K K'* through the core *C*, the pole *F*, the space *S*, the iron cover *L*, and the intervening space to the armature *A*, which is raised from *A' A'* to *A A*, thus bringing together the carbon contacts *D* and *E*, and delivering current to the car motors through the centre *O* and the collecting shoe *H*. The magnetic lines complete their circuit from *A* through *L'*, *S'*, *F'*, and *C'*, to the keeper *K K'*. When the magnetic field ceases to exist the carbon *E* falls by gravity to the "off" position.

It may be objected to this method of magnetisation that, in muddy weather, and when mud is frozen in winter, the magnetic influence is likely to become inefficient, with consequent arcing and injury to the carbon contacts. In answer to this point we must state that no inconvenience of the kind appears to have been observed in practice.

Fig. 9 contains a plan and sectional elevation of the car magnets and collecting skate, and Fig. 10 is an elevation of a motor track.

The magnets for operating the circuit closer are composed of yoke cores, the ends of which are connected by iron plates forming the two parallel poles. The poles are composed of a number of separate plates connected by pieces of wood as shown in Fig. 9. The energising coils are compound wound, the series winding being connected with the motors and serving to strengthen the magnet in case of need. A battery of eight accumulator cells is connected with the terminals of the series winding, the cells being required for starting the car from the depôt and in cases when the line current has temporarily failed. The cells are re-charged every two or three weeks.

Current is collected from the contact boxes by the skate shown in Figs. 9 and 10, this appliance being about 12 ft. long. The skate is shorter than the magnet poles in order that the circuit may be maintained until after the collector has passed away. This arrangement is intended to prevent the possibility of arcing within the switch boxes.

The collector skate, placed between the magnet poles, is composed of three continuous members, a contact strip of non-magnetic material, a piece of rubber and linen hose, and a timber support, the last being secured to the magnet yoke by bolts permitting any adjustments that become necessary from time to time.

In concluding this reference to the "Lorain" system, we are pleased to state that, judging from the accounts for the Wolverhampton Corporation Tramways for the year ending March 31st, 1905, the installation continues to show financial success, and although the working costs are somewhat higher than in

	Wolverhampton.	Average of Thirty-nine Undertakings.
Percentage of Costs to Revenue	59·3 per cent.	66 per cent.
Percentage of Gross Profit to Average Capital	6·9 ,, ,,	6·08 ,, ,,
Passengers per Car Mile	9·4	8·9
Journeys per Head of Population per annum	80	80
Revenue per Car Mile	10·898*d.*	9·75*d.*
Average Fare	1·15*d.*	1·12*d.*
Total Operating Costs per Passenger	0·69*d.*	0·78*d.*
Units per Car Mile	1·58*d.*	1·34*d.*
Repairs and Maintenance per Car Mile (including Electrical Equipment)	0·844*d.*	1·03*d.*
Management	0·77*d.*	0·92*d.*
Total Operating Costs per Car Mile	6·55*d.*	6·75*d.*

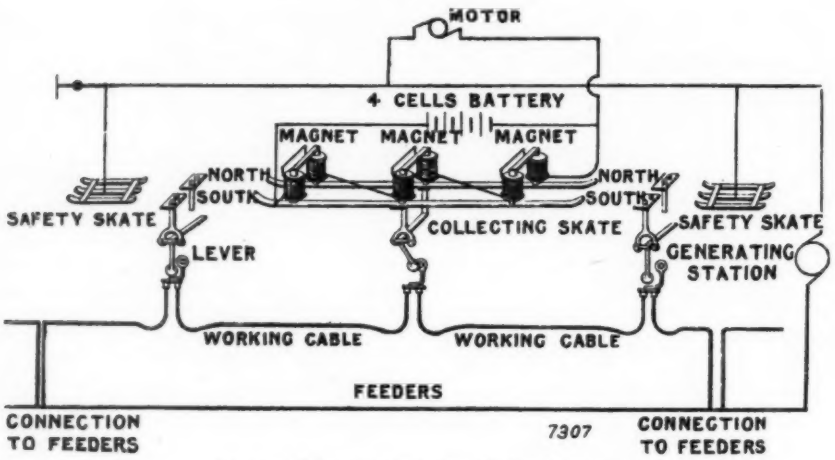


FIG. 11.—DETAILS OF CONNECTIONS. "DOLTER" SYSTEM.

favourable examples of trolley traction, they are certainly not higher than those of many municipal undertakings of the kind. The subjoined statistics are of interest as showing that the "Loraine" installation is a commercial as well as an engineering success.

Another method of furnishing intermittent connection between main conductors and tramway vehicles is that embodied in the "Dolter" system, which is offered in this country by The Dolter Electric Traction, Ltd., of London. It was installed in May, 1900, upon an experimental length of the Port-Maillot line belonging to the Bois de Boulogne Company, of Paris, and the results of the trial proved so satisfactory that the company were authorised by the Minister of Public Works to equip the whole length of their system upon the same principle.

Fig. 11 is a diagram illustrating the essential elements and connections of the apparatus. The collecting skate consists of two iron bars, hinged so as to permit lateral movement when curves have to be passed and bridged by electro magnets, one bar constituting the N and the other the S pole. The surface of each contact box is represented in the diagram by two plates, and beneath these are magnetic switches which will be described in more detail hereafter. The levers are pivoted at one end, the other end being free to rise when attracted by the magnetised skate. When so raised, as illustrated by the middle contact in the diagram, the lower end makes contact with a fixed block and completes the electric current between the main cable and the car motors. In the same diagram are shown the accumulator battery, the motor, two safety skates, the station dynamo, and the general scheme of distribution.

The contact boxes are placed in the middle of the track, their surface dimensions being about 9½ in. by 5 in., the upper part of the cover projecting slightly above the paving.

Fig. 12 is a section showing the construction of the contact box, which is carried by a cast iron chair embedded in asphalt or other insulating material. The box itself is of insulating waterproof material with an iron cover of the same material, but the projecting contact studs are separated by a piece of non-magnetic manganese steel.

An excellent feature of this system is the simplicity of the bell-crank lever forming the only moving part of the

switch. Being suspended freely on a simple pivot, it is positive in operation and far more likely to prove reliable than any form of switch mechanism working in guides.

In order to guard against the presence of live contacts after the passage of the collector, two safety skates are provided, one at each end of the car. In the event of contact being accidentally maintained, the skate establishes a short circuit by directly connecting the main conductor and the running rails, thereby blowing a fuse contained in the contact box.

It is stated that the energy expended in energising the car magnets is less than one per cent. of that used by the car, and that the sum of this loss and the losses due to leakage does not average more than 5 per cent. in excess of the energy required by the Trolley system.

The form of magnetised collector employed is a feature distinctly open to criticism, and we may add that the use of asphalt for supporting the contact boxes is even less likely to withstand heavy traffic than the artificial stone adopted at Wolverhampton. The simple character of the "Dolter" switch is the great recommendation of the system. This detail is of prime importance in every form of surface contact traction, for success largely depends upon the certainty of its action.

Let us turn now to the third example of the same general class, represented by the "G. B." system introduced by the Griffiths-Bedell Surface Contact Company, of London. The claims of this system have been fully supported by the extremely satisfactory operation of the experimental line which was in working order for more than a year at Ilford, and the recently completed tramway installation at Lincoln will shortly place further facts at the disposal of those who are interested in the most recent developments of electric tramway traction.

In this system the principles of road construction have received equal attention with those of electrical and mechanical engineering. Thus, the contact plates are securely supported by blocks of natural granite and a solid foundation is provided for the switch case and cable conduit. Further, the convenience of the public has been considered by the adoption of contact surfaces which are of small area, and do not project above the level of the paving. The electrical equipment is of simple character, and possesses features of distinct novelty.

The following is an outline description of the system. Current from the generating station is conveyed through a bare cable of galvanised iron, carried on insulators in a conduit formed of

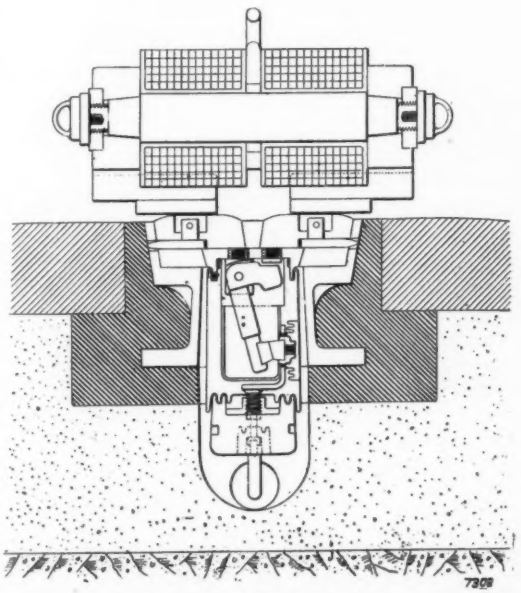


FIG. 12.—"DOLTER" SYSTEM. VERTICAL SECTION THROUGH SKATE, WITH ONE OF ITS ELECTRO-MAGNETS, AND THROUGH A CONTACT STUD, SHOWING LEVER MAKING CONTACT.

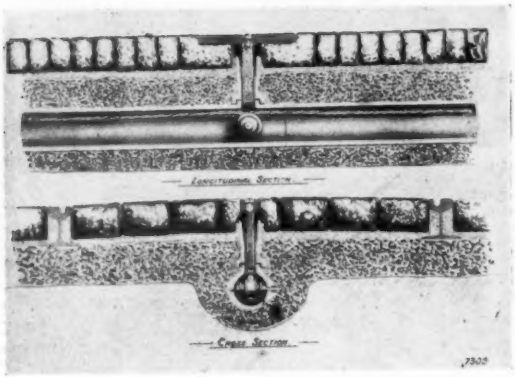


FIG. 13.—SECTIONS OF THE ROAD SHOWING METHOD OF CONSTRUCTION. "G. B." SYSTEM.

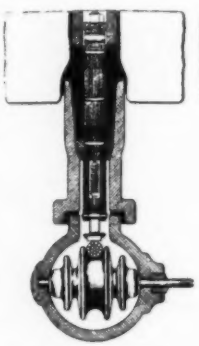
ordinary vitrified stoneware pipe, 5 in. diameter, laid below the centre of the track. Below each contact plate the conduit is provided with a T outlet. The conduit is jointed with bitumen, and is completely embedded in concrete as shown in Fig. 13. As the total depth of excavation never exceeds 19 in., and can be reduced to 6 in. where required, no removal or alteration of pipes already laid in the roadway is necessary. The insulators are of vitrified clay, and the pins on which they are mounted pass through the conduit on one side, and are joined by a horizontal strip of galvanised iron which is connected at intervals with the running rails. This simple earthing device affords an absolute guarantee that no contact plate can become "live" in consequence of leakages in the insulation surface separating the main conductor from the contact. By the arrangement in question, the Griffith-Bedell Company have succeeded in eliminating a defect which is one of the most serious objections against ordinary surface contact systems.

Access chambers placed at distances of from 200 yards to 400 yards apart along the route serve the combined purpose of joint and drainage boxes.

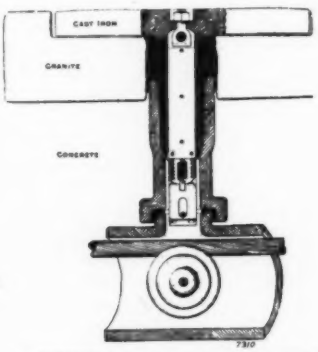
Fig. 14 shows a contact and switch in detail.

The contact plates are extremely simple, consisting of T-shaped pieces of cast-iron, the top part measuring 14 in. by 2 in., and bedded with bitumen into a setting of solid granite. The stem of the contact projects downward into the outlet of the conduit. The lower end of the stem is slotted out, and in the fork so formed a simple sliding switch-piece of iron, the only moving part, is supported on a spring of phosphor bronze wire, and slides between copper faces in the fork. At the lower end of the switch-piece a carbon contact is secured by copper clips, electrical connection with the stem being made by flexible copper leads.

The mode of operation is as follows:—When the magnet carried by a car passes over the contact plate, the stem of the contact is magnetised, and the sliding piece moves downward, partly through attraction towards the cable beneath, and partly repelled by mutual magnetic



CROSS SECTION OF CONDUIT THROUGH CENTRE OF STUD, SHOWING SWITCH PIECE DOWN.



LONGITUDINAL SECTION OF CONDUIT THROUGH CENTRE OF STUD, SHOWING SWITCH PIECE UP.

FIG. 14.—"G. B." SYSTEM

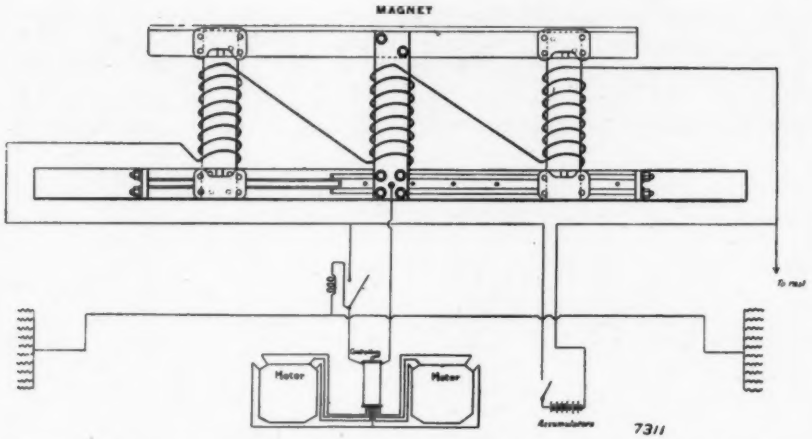


FIG. 15.—"G. B." SYSTEM. MAGNET WITH THE COLLECTORS IN OPERATION, AND A DIAGRAM OF THE ELECTRICAL CONNECTIONS ON THE CAR.

action between itself and the iron of the fork. Thus the carbon block comes in contact with the cable and current passes to the head of the contact plate where it is received by the collecting skate. Directly the car has passed and the contact plate ceases to be magnetic, the pull of the spring withdraws the carbon block from the cable and the plate is left absolutely dead. Of course this result can only be guaranteed so long as the spring remains effective, but as the maximum possible extension is well within the elastic limit no trouble need be anticipated. To give a further assurance, the spring is insulated in order that it may not deteriorate by having to convey current.

It will be observed in Fig. 14 that the joint between the stem of the contact plate and the upright pipe is made by a filling of bitumen, which is also run in the bedjoint of the plate as before mentioned.

The switch is more simple and far more compact than any other, although open to the objection that contact has to be broken by the agency of a spring. The direct contact of the carbon block with the main cable is another feature reducing the number of parts and saving the expense of providing and fitting short length of cable and other connections. Further advantages are presented by the position of the main cable and the compactness of the combined contact plate and switch, the design permitting the installation to be effected with very little disturbance of an existing roadway.

The devices carried by the car for collecting current and for magnetising the contacts are distinctive features of the system. Instead of being a rigid structure suspended above the roadway and impinging upon projecting contacts, the collecting skate is made of steel links joined together in the form of a chain, elastically suspended within one pole of the magnet, the bottom face of which moves over the contact plate. The collecting links at the ends of the chain are

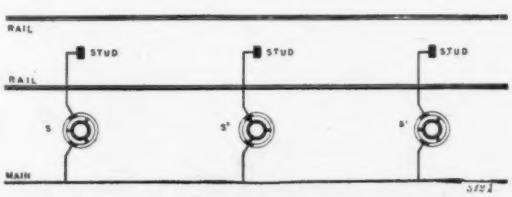


FIG. 16.—"KINGSLAND" SYSTEM. ARRANGEMENT OF SWITCHES, CONDUCTORS AND CONTACT STUDS.

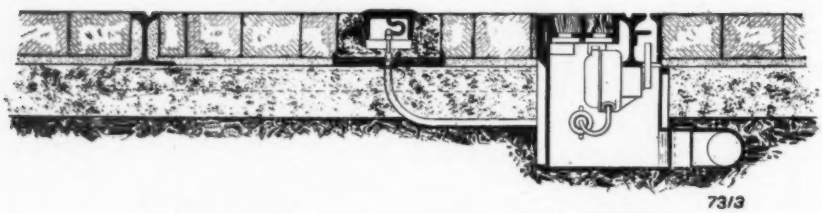


FIG. 17.—TRANSVERSE SECTION THROUGH TRACK. "KINGSLAND" SYSTEM.

loosely linked to the polar extensions so that the motion of the collector is limited in a horizontal direction. The collecting chain is fixed so that its normal position is about $\frac{3}{4}$ in. above pavement level, but when magnetised and passing over the head of a contact it is attracted downwards and slides along the plate in magnetic contact. By the provision of two such flexible collectors continuity is assured without sparking at the surface or switch contacts, and as a matter of fact, even on a dusty road there is less sparking at the contacts than at the trolley wheel of an overhead system under ordinary conditions.

The magnet can be actuated when the car is at a standstill by a set of six accumulator cells connected in series with the motors. Experiments show that the power used in maintaining the magnets is very small. Fig. 15 is a diagram showing the electrical connections of a car.

So far as concerns safety, we may refer to the ingenious device for eliminating any risk of live studs through leakage from the main conductor. The importance of this safeguard becomes evident when it is remembered that leakage is practically the only cause of live studs in other systems of good design. In case any defect should become developed in the switch mechanism, a short-circuiting chain trailing at the end of the car effectively sets an automatic circuit breaker in operation.

Finally, we have no hesitation in stating the opinion that this system of surface contact is one of the most satisfactory yet proposed. Like everything else, it is open to improvement, but for safety, sightliness, convenience, solidity, and simplicity of construction—especially in connection with the road paving — and general reliability, it constitutes a considerable advance upon the various foreign systems that are available for adoption at the present time. It is too early to make any comparison with the running costs of the Wolverhampton installation, as no figures will be available from the Lincoln tramway system for some months to come, but judging from the results obtained on the experiment line at Ilford we have every reason for anticipating an entirely satisfactory record.

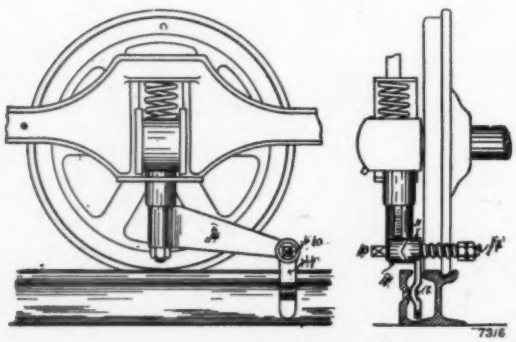


FIG. 18.—DETAILS OF STRIKER. "KINGSLAND" SYSTEM.

No review of surface contact traction would be complete without some reference to mechanical switch operation, a variation which is intended to obviate the objections entertained by some engineers to electro-magnetic

switches. The form of apparatus embodying this method of supply is well illustrated by the Kingsland Mechanical Surface Contact System, controlled by the Traction Corporation, Ltd., of Westminster. The first patent taken out by Mr. Kingsland in 1896 embodied a magnetic system, but finding that magnetic switches were not favourably regarded by British engineers, the inventor proceeded to evolve a mechanical system which has been modified from time to time as the result of three years' practical work on an experimental line established at Wolverhampton.

Fig. 16 is a diagram showing the arrangement of the conductors, switches, and contact studs. Switches s^1 and s^3 are in the "off" position, while s^2 is in the "on" position. The manner in which the switch is operated will be described later.

Fig. 17 is a transverse section of the track through a contact stud and street box. It will be seen that there is no mechanism in the contact stud, which consists of an outer block of granite and a removable metal portion of cast steel, bedded in bitumen, containing a screwed terminal and a short piece of flexible wire. The street box, through which passes a slot rail, is efficiently drained, and affords accommodation for the main cable conduit and a watertight switch, the latter being operated by means of a vertical lever protected from the interference of mischievous persons by a guard bracket.

Upon one front and one rear axle box of the car a striker is fitted, as represented in Fig. 18; the striker bars being cranked so as to pass the guard bracket.

The collecting skate is simply a steel tube of the section shown in Fig. 19. At the end of the skate the upper portion of the metal is tapered off, leaving a thin tongue which is curved in an upward direction. This gives a species of spring contact obviating shock and noise. The collector is suspended from the axles by a spring attachment insuring the requisite pressure and permitting the skate to adjust itself to inequalities of the road.

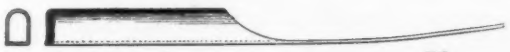


FIG. 19.—THE SKATE. "KINGSLAND" SYSTEM.

Apart from the motors carried by the car and the necessary connections, the above-mentioned parts constitute the entire equipment. For simplicity and absolutely positive action it would be difficult to imagine anything better suited to the requirements of a traction system.

The contacts have a superficial area of only 23 sq. in., with the projection of half-an-inch above the pavement level. They can be placed 14 ft. apart with a 6-ft. wheel base, and can be replaced at the cost of a few pence.

Owing to the absence of magnets and accumulators the weight of special car equipment is less than 2 cwt., as against one or two tons in the case of magnetic systems, and the consumption of current is practically the same as in overhead systems.

So far as concerns everything but the switches, the advantages of the apparatus are so perfectly obvious as to require no discussion. The only sources from which trouble may be feared are the switches and the rail slot. Therefore it is desirable to devote a few words to the consideration of these details.

The switch is enclosed in a watertight case bolted to one running rail, the only exposed part being the actuating lever.

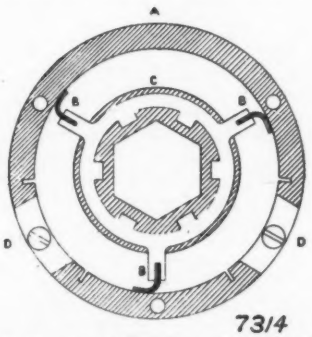


FIG. 20.—DETAILS OF SWITCH. "KINGSLAND" SYSTEM.

Fig. 20 is a section showing the outer case *A*, of insulating material, and the contact surfaces *D D* to which are connected the leads from the main cable and the stud, respectively. The central revolving piece *C*, of insulating material, carries a metal ring to which are connected the three brush holders *B B B*, in which are inserted the brushes, in contact with the inner surface of A. At every operation of the switch, the rotatory system is moved through one-sixth of a revolution, and the contacts *D D* are alternately connected and disconnected, whether the car moves forward or backward. The mechanism of the switch is an adaptation of the screw principle, and its operation is as follows:—The actuating lever being depressed in either direction, a screw is pushed forward on the spindle compressing a spring and causing a pawl ring to rotate, carrying with it a ratchet. By this train of movements the switch is turned to the "on" position. On liberation of the lever, the reverse action takes place and the impulse of the second striker restores the switch to the "off" position. Friction of the working parts is small, owing to the employment of ball bearings, and the switch is practically independent of lubrication. A doubtful point is whether the guard-rail will be sufficient to protect the switch from interference. This is a question that can only be positively answered by extended experience under actual working conditions, but there seems to be no reason for doubting the sufficiency of the arrangement proposed. It is possible, also, that some difficulty may be experienced in maintaining the slot at the specified width of five-eighths of an inch, unless the strength of the rail construction is increased. This, however, is a mere point of detail.

An objection raised by the advocates of electro-magnetic systems is that mechanical switches involve heavy wear and tear. On the other hand it is quite certain that magnets, accumulators, and magnetic switches do not obviate maintenance charges, and that they require current which has to be paid for. We do not see any real justification for the contention that a mechanical switch will be more costly to maintain than a series of delicate electrical appliances. Steam engines, gas engines, and machinery of various kinds have proved long ago that valves and gear can be operated by mechanical means without practical disadvantage.

In our opinion, the "Kingsland" system is clearly deserving of careful consideration, and it is quite possible that it may ultimately become a serious competitor of electro-magnetic systems. It is already beyond the experimental stage, being the only surface contact system in Dresden, where it is in daily operation under the control of the public authorities.

In the foregoing review of an important branch of tramway engineering we have endeavoured to make clear the undoubted advantages of, and at the same time to point out some difficulties connected with, the surface contact system of traction. The various types of design selected as examples have been briefly discussed on their merits. All of them possess good features, and naturally none of them are entirely free from disadvantageous features, which are to be found equally in every trolley and open conduit system. It is highly satisfactory to be assured that surface contact is no longer an experiment, and that the promoters of tramway undertakings have various really practical alternatives, costing little more than the objectionable trolley system, and far less than the extravagant open conduit system of construction.

The Single-Phase Electric Railway System.

By RUDOLF BRAUN.

THE evolution of electric traction started with the application of direct-current motors, and tramways and railways were operated successfully thereby for short distances. The main drawback to the direct-current system, however, is the difficulty of transmitting the energy economically over long distances; for under these circumstances it is necessary to use alternating current for transmission, and direct-current for the actual working of the line. This combination makes it possible for a railway system to extend over an area of which the average distance from the power station may be much greater than with an entirely direct-current system.

In order to effect the transformation from alternating current to direct-current, suitably located sub-stations equipped with the necessary apparatus to effect the transformation are necessary. These sub-stations contain either rotary converters or motor-generators with step-down transformers. The cost of such sub-stations and the operating expenses of same, however, render the system unsuitable for long distance transmission, so that its application is limited commercially to tramways and suburban railways; and extensions are justified only when the traffic is sufficiently dense to cover the expenditure.

The extended experience gained from the commercial working of such systems has demonstrated that for economical working the maximum distance between sub-stations must not exceed ten miles, unless the traffic along the line is exceptionally light, and cars or trains infrequent. In a mixed system the distribution cables comprising the low voltage direct-current feeders to the conductor rails and over-head trolley conductors represent a large proportion of the capital expenditure. The single-phase system obviates the use of rotary converters or motor-generators and materially reduces the switch-boards required in sub-stations; while the low tension cables of the direct-current distribution system are eliminated. On the other hand, single-phase car equipments are a little more expensive than direct-current equipments. In comparing many projects worked out for both the direct-current and single-phase systems it is seen, however, that the capital expenditure for the latter is always considerably lower than that for the direct-current system.

In fact, the only conditions under which the direct-current system can compete favourably with the single-phase system are when the line is very short, and the volume of traffic so small that no sub-stations are required, and low-tension direct-current feeders of small dimensions can be used. This applies generally to systems employing not more than from thirty to fifty cars; and, even in such cases, it will often be found that the advantages of the single-phase system make such an installation preferable to a direct-current one.

With the single-phase system the limit of the trolley voltage depends largely upon local conditions, and almost any voltage of transmission within the bounds of safety and economy may be adopted.

Transmission pressures of 40,000 to 60,000 volts have already been successfully used on the Continent and in America, and while 10,000 volts on the trolleys wires has been found quite

reliable, yet, for reasons of safety and economy 6,600 may be accepted as the maximum pressure of the near future.

Methods of insulating high-tension wires and cables have been so considerably improved that high pressures are not now more dangerous to the public than the lower pressures of the direct-current system.

FIG. 1.—"WESTINGHOUSE" SINGLE-PHASE LOCOMOTIVE (WEIGHT, 135 TONS) HAULING A TRAIN OF 1,200 TONS.

The single-phase system as a whole comprises the following parts:—

1. The power station equipped with single-phase or polyphase generators driven preferably by means of steam turbines, otherwise by reciprocating engines, water turbines or gas engines. 2. Step-up transformers for delivering the energy at high-tension to the transmission line. 3. The high-tension transmission line. 4. Sub-stations equipped with step-down transformers to deliver energy to the trolley wire. 5. The overhead-trolley wires. 6. Cars or locomotives equipped with single-phase apparatus. 7. A return circuit through the track system properly bonded, or an independent return wire.

(1) It is not necessary to use single-phase generators, as the different phases of a polyphase system may be loaded independently as long as the load is distributed with reasonable uniformity on the several phases.

In considering the generators alone, one must bear in mind that single-phase generators would in general prove little more costly than three-phase generators of equal capacity. In fact, for equally good regulation, with sets driven by steam turbines, the price of single-phase generators is practically the same as that of three-phase generators having the same capacity.

(2) Step-up transformers are not necessary in the power station if the transmission voltage can be generated directly by the alternators. If, however, the transmission voltage is relatively

high for the capacity of the generators, step-up transformers are necessary, since the insulation on the stationary transformer is much more reliable than that of the high-tension winding distributed in the slots of a generator: further, the transformers serve to protect the generators against damage from lightning and static disturbances caused by switching or short circuits.

(3) An important point in transmission which concerns the safety of the public is the tension between the overhead conductors and earth, and this must necessarily always be carefully considered. The quantity of copper under this condition is, with a three-phase transmission system, the same as with the single-phase system. In consequence of the extra set of insulators and supports required for the third wire, the cost of the three-phase transmission line is actually greater than that for single-phase transmission.

(4) The transformer sub-stations may be located along the track at suitable points, and with high trolley-voltages and conductors of ordinary size, can be placed much further apart than the rotary transformer sub-stations of the mixed system. The distance between these sub-stations is only limited by the trolley voltage, and permissible drop in voltage compatible with economic working: and with these fixed at reasonable limits, this distance may be as great as twenty miles. In consequence fewer sub-stations are needed, and large and economical units can be employed. A sub-station equipped with static transformers is cheaper in first cost, maintenance, and operation than a sub-station of equal capacity equipped with rotary converters or motor generators. Static transformers need little inspection, and can easily carry for short periods an over-load of several times their normal load, and in consequence the normal aggregate capacity of the sub-stations will be less than for sub-stations worked on a mixed system, and yet have a greater emergency capacity.

(5.) The overhead conductor system which supplies the high-tension energy to the motor vehicles is quite reliable. The trolley conductor is out of reach of men working on the permanent way, while the live third-rail on the ground level is a continual source of danger to them. The catenary construction which has been adopted with such signal success, for the suspension of the trolley conductors, is as proof against breakdown as a suspension bridge: and it is highly improbable that the steel suspension cable—with the very light load of the suspended copper wire, sometimes added to by snow, or icicles—will break, if designed with a proper factor of safety and intelligently installed. Iron or wooden poles carrying the catenary construction are entirely safe, and not likely to be over-strained even with the weight of snow

FIG. 2.—SECTION OF SINGLE-PHASE CATENARY LINE BRIDGE CONSTRUCTION FOR HEAVY TRAFFIC.

and ice on the wires. The trouble of obtaining good contact, owing to adverse climatic conditions which has sometimes proved so serious with the third-rail that the service has had to be suspended, is not likely to arise with the over-head single-phase line.

In case of collisions or other accidents there is less liability of fire. One point has rarely been mentioned, which will appeal strongly to practical men, namely, it is not necessary to break the continuity of the conductors at level crossings. No difficulty is experienced in having the proper clearance on trucks, cars, and locomotives to prevent short circuits. The cost of the over-head conductors can, within wide limits, be adjusted to the density of the traffic.

(6.) The electrical equipment of the vehicles is, with the single-phase system, more simple than that of the direct-cu rrent system. This is due to the fact that less than one-half the number of notches are necessary on the controller in order to secure the same limitations of current during the starting period with equivalent weights and under similar conditions. Magnetic blow-outs are only required for exceptionally heavy currents, and, owing to the absence of resistance boxes, and the smaller number of unit switches, the multiple-unit system for manipulating all the controllers from any convenient part of the train becomes simpler. The commutation of the single-phase railway motor is equally as good as that of the direct-current motor, and superior in the fact that the brush-holders may be short-circuited or grounded without any flashing at the commutator. It is also impossible to flash the commutators even when a deliberate attempt is made to do so.

The full working voltage may be thrown on the single-phase motor and it may be reversed whilst running, provided the gears are strong enough to stand the mechanical shock; and neither of these abuses will damage the motor or its commutator.

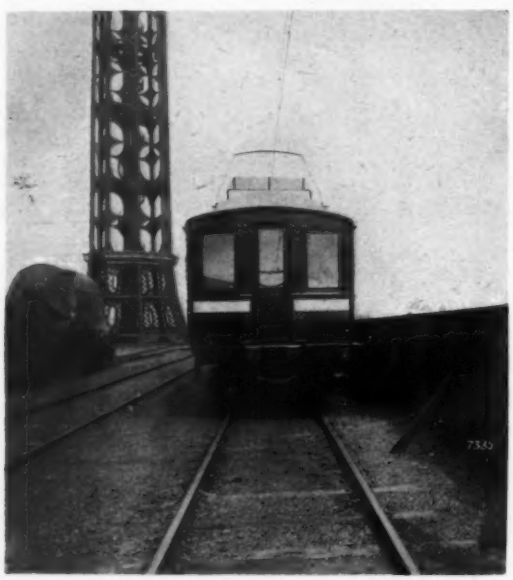


FIG. 3.—"WESTINGHOUSE" SINGLE-PHASE MOTOR CAR AT TRAFFORD PARK.

Foremost among single-phase railway motors which have proved successful in commercial working is the series neutralized type, operating at 25 cycles with 250 volts across the motor. The low pressure at the motors renders it an easy matter to insulate them, so that there is less chance of a breakdown than with the 500-volt direct-current type. Every electric railway manager knows that even the best insulation on a motor will deteriorate and become deficient after a few years' operation. This being so, the lower the pressure on the motor the less strain on the insulation, and the longer will the motor continue to operate before breaking down. This point cannot be emphasized too much, in view of the fact that motor repairs in an electric railway system generally demand an appreciable outlay.

The weight of the best-designed single-phase railway motor on the market is about the same, or slightly less, than that of a direct-current motor of equal capacity.

Assuming a train weighs 150 tons the transformer on the motor coaches does not increase the weight by more than 2 per cent. This means 2 per cent. higher energy consumption in moving the train, but this is largely compensated for by the elimination of resistance losses, and the saving of energy in the highly efficient sub-stations.

The method of control of the single-phase motors is an ideal one, in many respects, for the speed of the vehicles does not depend directly upon the trolley voltage or the frequency, and the resistance losses which occur in the direct-current system, both when starting and running at intermediate speeds, are entirely eliminated. The saving of energy dissipated in resistances is especially marked under conditions of frequent startings, or when the rate of acceleration is necessarily low.

FIG. 4.—CONTROLLER WITH AIR BRAKE ON A SINGLE-PHASE MOTOR CAR AT TRAFFORD PARK, INSTALLED WITH FOUR 100 H.-P. SINGLE-PHASE MOTORS.

Under normal conditions the acceleration which can be obtained with single-phase motors is exactly the same as the acceleration by direct-current motors. This is due to the fact that the acceleration with a given mass always requires a certain torque whatever motor be used; and motors of the same capacity, whether for direct or single-phase current, can—with suitable gear ratio—always produce the same accelerating effect on trains with weights and velocities corresponding to the capacity of the motors.

At the end of the line, with a high drop in the over-head conductor, the speed may be reduced, but it can easily be increased to the desired amount by providing for taps on the secondary of the auto-transformer. Thus the speed regulation of the single-phase equipment is effected by varying the transformer ratio, and is independant of the line voltage and frequency. Direct-current motors with series-parallel control have only two economical speeds, and there is no possibility of running faster with a low line voltage. The three-phase motor in this respect is still more inferior. With a heavy drop on the line, the speed of the motor decreases in maintaining the same torque, resulting in an increased secondary loss, and, in consequence, diminished efficiency. With three-phase motors connected in cascade there are only two economical speeds.

One of the characteristics of the single-phase motor, which is common also to the direct-current motor, makes it particularly adaptable to railway traffic, namely, the fact that its torque increases as the current increases, and with a given voltage is a maximum at the lowest speed. The single-phase

motor is, therefore, very elastic in respect to over-loads. On the grades necessitating high torques the speed is reduced automatically, and the motors demand less energy from the power station when operating on grades, than the polyphase motor under similar conditions.

Having dealt with the subject from a general point of view, a few particulars may be given of the work which is being done in America and in England.

In Fig. 1 is shown a single-phase locomotive built by the Westinghouse Company for heavy railway service. It is the largest locomotive in the world equipped with single-phase apparatus. The equipment comprises six of the largest single-phase motors ever built, each being of 250 h.-p. capacity. The weight of the complete locomotive is 120 tons. It is of the *articulated* type, each half being mounted on a six-wheeled truck. The two parts are coupled together and operated as a single unit, but each half may be operated separately if necessary. Each axle is driven by a 250 h.-p. single-phase series motor with single reduction gear.

The trolley voltage is 6,600 volts, at 25 cycles, and the current is collected by pneumatically operated trolleys, and is then carried through an oil-break circuit-breaker to an auto-transformer on each of the car bodies.

The motors are operated at from 140 to 325 volts. The steady drawbar pull when hauling a 1,214 ton freight train with the brakes set on the four rear cars as recorded by a dynamometer, is from 80,000 to 85,000 lbs. with a dry and sanded track. The maximum speed of the locomotive with light loads is thirty miles per hour.

One of the most notable applications of the single-phase traction system will shortly be seen on the New York, New Haven and Hartford Railroad Company's lines. Single-phase locomotives have been adopted for express train service, and they will be arranged for operation either by single-phase alternating-current or by direct-current. This arrangement is necessary as the passenger trains on this road entering the Grand Central Station in New York City have to pass over the tracks of the New York Central Railroad for a distance of 12 miles. The latter line is at present equipped with direct current, and it was therefore necessary that the New Haven trains should run with direct-current over this twelve miles of line.

This is the first example of the introduction of the single-phase system by one of the leading main railroads of the United States, and it is a notable advance in electric traction. This development in main line working is worthy of careful thought and study in view of the congested conditions of traffic on many existing main line railways now operated by steam, which lines will shortly be driven to seek some means of relief.

Locomotive and Railway Notes.

By CHAS. S. LAKE.

The London and North-Western Railway "Experiment" Class Locomotives.

THE notes for August contained a photographic reproduction of the first of the new 4-6-0 type locomotives, viz.: No. 66 "Experiment," designed by Mr. Geo. Whale, M. Inst. C. E., chief mechanical engineer, for working heavy passenger trains, on the northern sections of the London and North-Western Railway main line, viz.: between Crewe, Preston and Carlisle.

The particulars then given are supplemented in the present issue by sectional elevation and plan drawings of the new class of engine, which provide further information relating to the same. The drawings show that Mr. Whale has retained the central frame and bearing for the crank axle which Mr. Webb fitted to several classes of locomotives in his time, and which form of construction possesses undoubted advantages. It necessitates the employment of a type of valve gear in which eccentrics are absent—in this case it is Joy's radial gear,—unless, of course, the designer chose to place the steam chests and valve motion outside the frames, whilst retaining inside cylinders; but few engineers in this country would favour such a plan, there being several objections to it, whilst the advantages to be derived are exceedingly doubtful ones.

The ash-pan, as will be seen, is lifted to clear the intermediate coupled axle, but it is fairly deep on both sides, front and back. The trailing axle is placed at the rear of the grate altogether. This arrangement of axles permits of a relatively short, rigid wheelbase being obtained, the actual figures in this design being 13 ft. 7 in. The total wheel-base is 26 ft. 8 in., which might easily have been reduced 18 in. to 2 ft. by using outside cylinders with the middle pair of coupled wheels as drivers. This would have meant a shorter boiler, but a larger diameter of barrel could have been introduced, without pitching the axis any higher above rail level than at present; the inside cranks being absent. Mr. Whale, however, prefers to employ inside cylinders, and he has certainly succeeded in producing a handsome and effective engine, and one which ought certainly to give satisfaction. The writer is informed that the "Experiments" are performing prodigious feats on the heavily-graded sections north of Preston, hauling trains weighing nearer 400 than 300 tons, unaided, at high average speeds, and taking assistance only on Shap Incline with the heaviest trains.

The design is simple and straightforward; it is thoroughly typical of the most modern British locomotive practice, and Mr. Whale is to be congratulated upon it: but why "Experiment"?

New Rolling-Stock on an Indian Railway.

THE Great Indian Peninsula Railway has recently introduced some excellently designed corridor trains on the Bombay-Poona service, the trains consisting of seven bogie cars with central corridors or gangways, and the make up including a restaurant car of the most comfortable and well-appointed description.

The accompanying photographic illustrations show the exterior and interior of one of the new vehicles, and it will be at once recognised from these that the design and equipment are at least equal to those met with on the trunk lines of this country. The car runs upon two four-wheeled bogie trucks, spaced at 40 ft. between centres, each bogie having a wheel-base of 10 ft. The under-frames are of steel channel sections, 9 in. × $3\frac{1}{2}$ in. × $\frac{7}{16}$ in., and the length of car over headstocks is 60 ft. The dining tables are arranged at the sides of the gangways, four persons being accommodated at each table. Polished mahogany is employed for the arm-chairs and other furniture in this car, the sides of which are handsomely panelled, the decorations including large framed photographs and plate glass screens, whilst sideboards of ornamental design are also provided. A portion of the vehicle is partitioned off as a kitchen and pantry. The former contains a gas cooking range, a high-pressure water filter and exhausting fan for reducing the

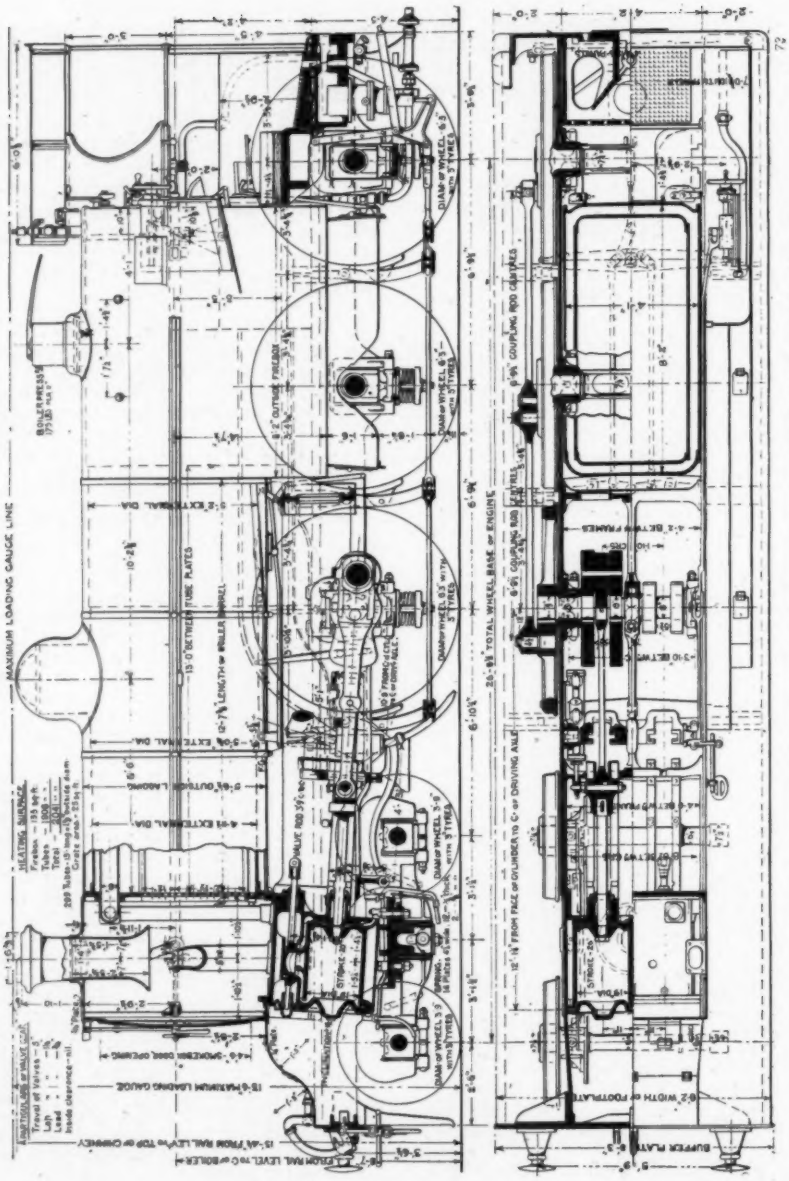

MAXIMUM LOADING GAUGE LINE
HEATING SURFACE
Firebox — 193 sq.ft.
Tubes — 1,890 "
Total — 2,083 "
Grate area — 31½ sq.ft.
BOILER PRESSURE
175 lbs. per sq.in.
15'-0" BETWEEN TUBE PLATES
6'-0" DIA. OF COUPLED WHEELS
6'-6" DIA. OF COUPLED WHEELS
6'-9" DIA. OF COUPLED WHEELS
6'-6" COUPLING ROD CENTRES
20'-9½" TOTAL WHEEL BASE OF ENGINE
15'-6" MAXIMUM LOADING GAUGE
15'-4¾" FROM RAIL LEVEL TO TOP OF CHIMNEY
BUFFER PLATE
FOOTPLATE

FIG. 1.—4-6-0 TYPE EXPRESS LOCOMOTIVE "EXPERIMENT," LONDON AND NORTH-WESTERN RAILWAY.

temperature. The pantry is well equipped for its purpose, and there are also servants' quarters and other accommodation. The car is not provided with sunshades, but it has a clerestory pattern roof in which is incorporated a layer of non-conducting asbestos material as protection against the heat of the sun. Ample window spacing is provided, and electric punkahs are employed for keeping the atmosphere cool.

There are seven cars in the train, first, second and third class, special smoking lounges and separate ladies' saloons are included, these being features much appreciated by the passengers. The complete train measures nearly 450 ft. in length; the cars are 62 ft. long over all, and 10 ft. wide, the end doors being recessed to 9 ft. 6 in. Other dimensions common to each carriage are :—

Height from rail to top of clerestory roof	12 ft. 10½ in.
Height of inside body...	8 ft. 4½ in.
Extreme length over vestibules	63 ft.
Average weight...	34 tons.
Seating capacity (first class) ...	50 passengers.
,, (second class) ...	95 ,,
,, (third class) ...	320 ,,

The Bombay-Poona vestibuled mail covers the 119 miles separating the two cities in 3 hours 45 minutes, which, considering the gradients encountered, is a distinctly meritorious performance. The scenery—as the writer can testify from personal observation—is amongst the most wonderful met with in this part of India.

The train on arriving at Khandalla has ascended to a height of 2,000 ft., and passengers are afforded the spectacle of a continually unfolding panorama of mountains, rivers and valleys, whilst making the ascent. The later stages of the journey, through the uplands of the Deccan, are performed at a high rate of speed, and the whole trip constitutes a memorable experience for those visiting India, the pleasures of which have now been materially added to by the introduction of the new trains. The designer is Mr. A. M. Bell, M.Inst.C.E., carriage and waggon superintendent of the Great Indian Peninsula Railway, and the work of building was carried out at the company's Parel workshops.

In addition to the foregoing corridor expresses, the Great Indian Peninsula Company have lately introduced a new type of suburban passenger train, comprised of six cars of the most modern description. One of these trains is illustrated in Fig. 2. The cars have central corridors and reversible seats. The bodies are 62 ft. in length by 10 ft. wide, over-mouldings and the same

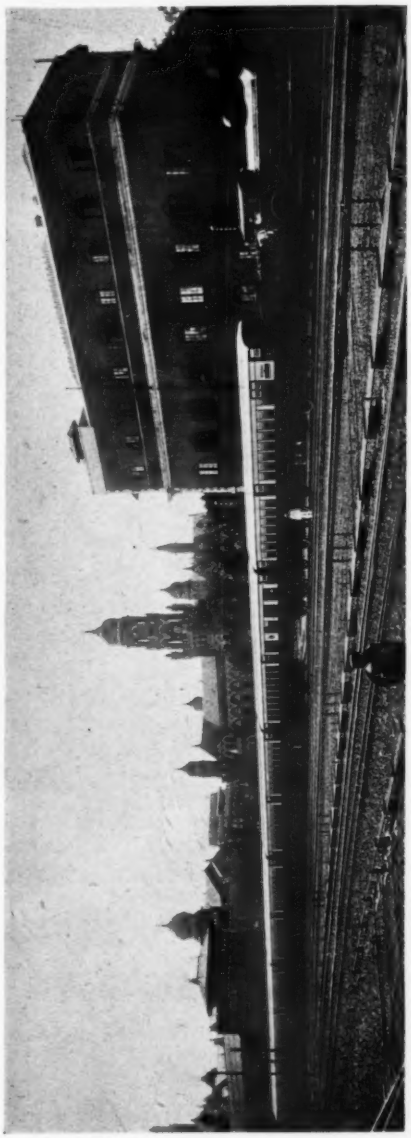


FIG. 2.—SUBURBAN PASSENGER TRAIN, GREAT INDIAN PENINSULA RAILWAY.

pattern of clerestory roofing is used as in the main line passenger stock described above, sunshades being dispensed with. Steel under-frames support the bodies, and each car is mounted upon two four-wheeled bogies, the axles of which are spaced 10 ft. apart.

Each vehicle has six doors, viz., two at each end and two in the centre, after the manner of the new electric cars on the District Railway of London. The doors on the Great Indian Peninsula trains open inwards, however, instead of sliding, as in the other case referred to.

FIG. 3.—NEW CORRIDOR TRAINS, BOMBAY-POONA SERVICE: INTERIOR OF ONE OF THE VEHICLES.

Electric lighting and fans are installed, the dynamos and batteries being located under the brake vans, with switches and regulating gear in the guard's compartment. Seats for 533 passengers are provided, and, in addition, there is both lavatory and luggage accommodation. Filtered drinking water is supplied throughout the train; the third class seats are upholstered in dark green leather, and the first and second class in teak and "augar chan" wood, the ladies' compartment being upholstered in blue, and painted cream colour. Suburban passengers in this country would consider themselves fortunate to obtain such train accommodation as that just described. The conditions of travel are, of course, different here, and it is to the new electric trains that we must look for increased comfort.

Variable Exhaust for Locomotives.

THOSE who follow the subject of locomotive engineering will not need to be reminded of the trouble engineers are put to in the effort to overcome that terrible bugbear "sparking," which not only spells lack of economy in fuel consumption, but also plays wholesale havoc with the tubes and the tube plates of the boiler. But, to be successful, a device put into a locomotive to obviate the spark-throwing evil must not, in any material degree, interfere with the steaming qualities of the engine, and this is just what some otherwise satisfactory appliances have the tendency to do, with the result that they have to be removed, in spite of the excellent results they produce in keeping the sparks down. Notable exceptions are not wanting, either in this country or

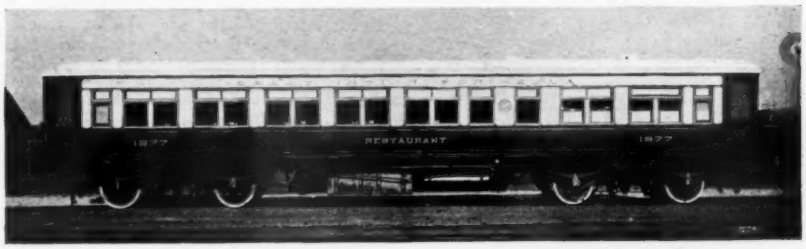


FIG. 4.—NEW CORRIDOR TRAINS, BOMBAY-POONA SERVICE: VIEW OF THE RESTAURANT CAR.

abroad, and an American inventor has recently added to the number in existence a device which would seem to be capable of achieving what is required of it, without interfering with the free escape of the exhaust steam from the blast pipe.

This device, which is known as the "Wheaton" variable exhaust, after the name of its inventor, allows the exhaust steam to escape, at certain times and under certain conditions, through a separate pipe outside the chimney. The working of the apparatus is automatically dependent upon the manipulation of the reversing lever or wheel, the pressure of the exhaust in the chimney being directly consequent upon the relative position of the reversing lever upon the quadrant. Matters are so arranged that when the lever is on the front notch and the engine therefore in full gear, the separate exhaust is at its maximum opening, which opening is gradually reduced as the gear is linked up to the position required to meet the conditions of running. Thus the later the cut-off of the slide valves the larger the amount of opening of the auxiliary valve, so that in this way the area available for the escape of exhaust steam is graduated in proportion to the volume to be discharged. The device is intended to cause a mild and even draught through the tubes sufficient to cause the coal to burn properly without interfering with the free steaming of the engine, and Mr. Wheaton claims that by the use of his appliance a thinner fire can be carried, a saving in fuel is effected, the tubes last longer, and spark throwing is reduced.

A New Form of Locomotive Crank-Axle.

MR. H. A. IVATT, M.Inst.C.E., chief locomotive engineer of the Great Northern Railway, has designed and patented a crank-axle mainly intended for use in connection with locomotives, but which may also be applied to other types of engines. Mr. Ivatt aims at securing greater flexibility in the axle, and reducing the liability of fracture caused by a too rigid construction. The axle is so designed that the increased flexibility is secured whilst keeping the two cranks closely adjacent to one another, and it is claimed that by constructing the axle as shown in the accompanying illustration a more perfect balancing of the axle is obtained, whilst the renewal of the parts is facilitated and cheapened.

The axle is made in two sections, and, as will be seen, the inner crank arms are prolonged, the extended portions being jointed together and firmly secured by turned bolts and nuts. The joint or coupling so formed may be adapted and adjusted to counterbalance the weight of the two cranks, which are arranged at an angle of about 90 degrees, thus producing a more perfectly balanced shaft. The two sections of which the axle is comprised may be partly forged or built up as desired, and in case of injury either of these sections may be renewed without interfering with the other section.

New Express Locomotives for the Midland Railway.

THE writer has been favoured by Mr. R. M. Deeley, M.Inst.C.E., locomotive engineer

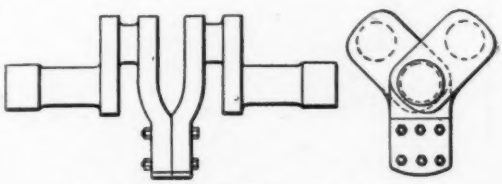


FIG. 5.—NEW FORM OF LOCOMOTIVE CRANK AXLE.

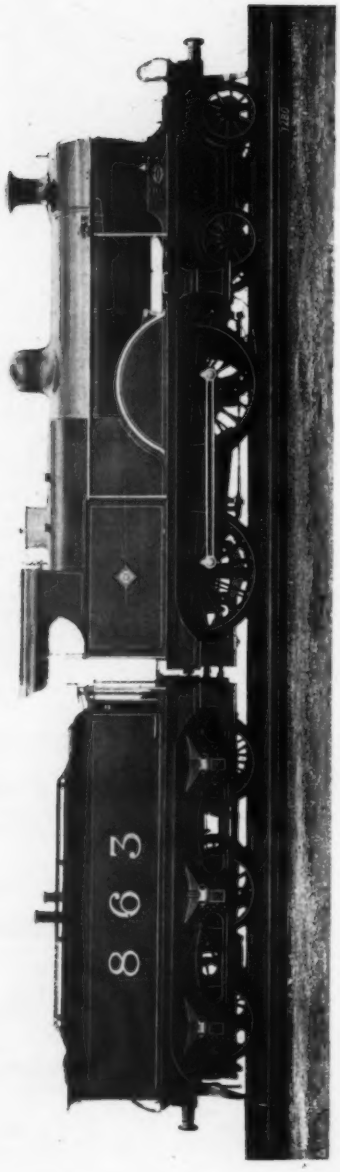


FIG. 6.—4-4-0 TYPE EXPRESS LOCOMOTIVE, MIDLAND RAILWAY.

of the Midland Railway, with a photograph and particulars of engine No. 863, one of a new series of four wheels coupled bogie locomotives recently completed at Derby works, from his designs, for working heavy and fast main line express passenger traffic. The new engines bear a strong resemblance in appearance to some previous locomotives, of which a large number are already at work on the Midland Railway. They have the 4-4-0 wheel arrangement, inside cylinders and the "Belpaire" pattern of boiler, but in this new series the working steam pressure has been raised from 180 lbs. to 200 lbs. per sq. in. The drumhead tube-plate at the front end has been replaced by one of ordinary pattern, and the necessary modifications in the design of the smoke-box have been made to suit. The smoke-box door is secured by means of six dogs in place of the usual centre fastening. This arrangement is found to keep the doors tighter, and therefore to be more effective in preventing the in-drawing of air. The side sheets of the cab have been made a little deeper, and the roof extended back over the footplate and front part of the tender. This is a great improvement over previous Midland practice, and will no doubt be much appreciated by the enginemen. The design is exceedingly neat and symmetrical, and the general appearance is undoubtedly pleasing, if we except the one feature of the emblazonment on the sides of the tender, in extra large-sized figures, of the engine number, *à la* American practice.

The principal dimensions are as follows:

Cylinders dia.	19½ in.
Piston stroke	26 in.
Wheels (coupled) dia.	6 ft. 9in.
„ bogie dia.	3 ft. 3½ in.
Boiler, centre line above rails ...	8 ft. 3 in.
„ diameter of barrel (inside) ...	4 ft. 8in.
„ length „ „	11 ft. 0 in.
Length of firebox shell	8 ft. 0 in.
Grate area	25 sq. ft.
Heating surface:—firebox	145 sq. ft.
„ „ tubes	1,310'5 sq. ft.
„ „ total	1,455'5 sq. ft.
Working steam pressure	200 lbs. per sq. in.
Wheelbase:—rigid	9 ft. 6 in.
„ total (of engine) ...	23 ft. 5½ in.

The engine, without its tender, weighs 53 tons 10 cwts. 2 qrs. loaded, of which 35 tons 9 cwts. 3 qrs. is available for adhesion. The tender is fitted with water pick up apparatus, has a water capacity of 3,500 gallons and weighs 41 tons 8 cwts. 3 qrs. loaded. The total weight of engine and tender in working order is therefore 94 tons 19 cwts. 1 qr.

High Railway Speed.

THE writer has been taken very severely to task by a correspondent for having stated, in the September notes, that very high railway speed was not a desideratum of the general travelling public. This gentleman asserts that average speeds of 60 miles per hour and upwards *are* to be desired, and can not only be easily accomplished, but would be, without doubt, a direct source of increased income to the railway companies who will adopt them. He does not support his contentions by anything in the way of argument, merely stating that from "observations made" he is able positively to assert that the public *do* require these high railway speeds and will eventually get them. The correspondent referred to, let it be said, is not an engineer, indeed he is known to the writer to have no practical knowledge of engineering matters, neither has he any connection whatever with any of the railway companies, so that he cannot claim to speak with authority. Everyone is, of course, entitled to their own opinions, but the writer would prefer to be guided in this, as in other matters of a similar kind, by the utterances of competent and experienced locomotive engineers, rather than by those of non-professional and non-practical "experts."

Steam Motor Coaches: Northern Counties Committee.

THERE have recently been completed at the Midland Railway Company's Works, Derby, two steam rail motor coaches for working on the Belfast and Northern Counties section of the line. The writer has been favoured by Mr. R. M. Deeley with a photograph and particulars of one of the cars, and as will be seen therefrom the engine is of the locomotive type, separate from the coach itself. The cylinders are placed outside the frames and drive the end pair of wheels which, in this design, are not coupled to the second pair. Steam is taken from the dome and passes through pipes outside the boiler to the cylinders which have flat valves actuated by Walschaerts' motion working above them.

The carriage portion is divided into several compartments, including one smoking and one non-smoking for third class passengers, a first class saloon, a luggage room, and a driver's compartment at the rear end.

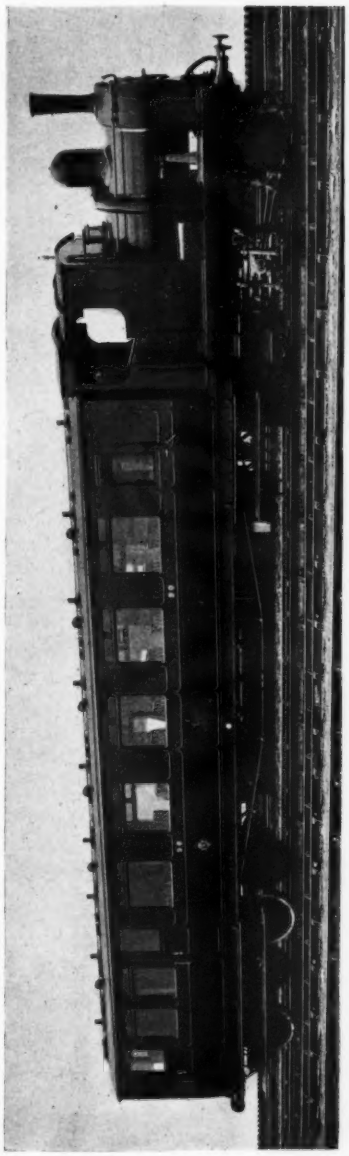


FIG. 47.—STEAM MOTOR COACH: BELFAST AND NORTHERN COUNTIES COMMITTEE.

The cars are for service between Greenisland and Antrim, where several new haltes have been instituted.

The following are some leading particulars :—

Cylinders	9 in. dia. by 15 in. stroke.
Boiler, mean diameter of barrel inside ...	3 ft. 7⅛ in.
,, thickness of plates	½ in.
,, length of barrel between tube plates	4 ft.
,, 139 brass tubes	1¾ in. outside dia.
Length of firebox, shell	3 ft. 1 in.
Heating surface, firebox	51 sq. ft.
,, ,, tubes	262 ,, ,,
,, ,, total	313 ,, ,,
Grate area	7·6 ,, ,,
Wheel-base, engine bogie	10 ft.
,, carriage bogie	8 ft.
,, centres of bogies	39 ft. 7½ in.
Length of buffers	60 ft. 5½ in.
Diameter of wheels, engine driving ...	3 ft. 7½ in.
,, ,, engine trailing ...	3 ft. 3 in.
,, ,, carriage	3 ft. 6 in.
Water capacity of tank	500 galls.
Coal capacity	11½ cwts.
Number of Passengers, 1st class	6
,, ,, ,, 3rd class	40

The weights as determined at Belfast are as follows :—

	T.	C.	Q.
Empty, driving	14	16	0
,, trailing	8	4	0
,, carriage bogie...	12	10	2
Total	35	10	2
Working, driving	16	2	0
,, trailing	9	8	2
,, carriage bogie	13	12	2
Total	39	3	0

An American Version.

ACCORDING to *Railway and Locomotive Engineering* of New York, the designs of No. 1300 engine on the Great Northern Railway of England (which is the four-cylinder compound locomotive recently built at the Vulcan Foundry Company's Works at Newton-le-Willows), "were worked out by Mr. Bodmer of the *Model Engineer*, since deceased, from specifications provided by Mr. Ivatt." Whatever there is to be said about the engine, most people will hesitate to accept the above grotesque statement as representing the truth.

Rail Motor Cars: London and North Western Railway.

THE steam rail motor coaches which have been built at Wolverton and Crewe works for branch line service on the London and North Western Railway, have bodies 57 ft. long at the centre, and 55 ft. 6 in. long at the sides. The ends are rounded off, and the width over all is 9 ft.; the height at centre being 8 ft. 5 in., and 6 ft. 7 in. at side cornice, all of these being outside dimensions.

Two large passenger compartments are provided; these are 16 ft. long, by 8 ft. 8 in. wide, and there is a vestibule between the two measuring 3 ft. 9 in. wide, by 7 ft. 6 in. long. This vestibule provides a means of access for passengers to the compartments, and is under the control of a conductor. The seats, which are arranged transversely on each side with gangways down the centre, are double and reversible so that passengers can face the direction in which the car is travelling, except in the case of the end seats which are fixed. The seats and backs are supported in iron frames and are covered with closely woven rattan; they are of comfortable and roomy design. The number of passengers carried in each compartment is twenty-four, or a total seating capacity for the car of forty-eight. The finishing of the compartments except the luggage room, which is next the engine and measures 4 ft. 5½ in. wide by 8 ft. 5 in.

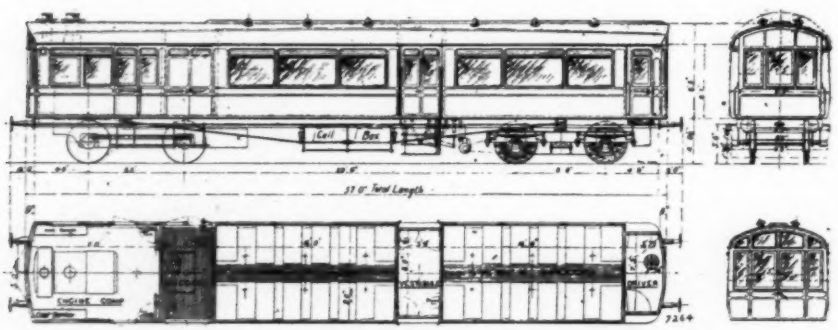


FIG. 8.—RAIL MOTOR CAR: LONDON AND NORTH WESTERN RAILWAY.

long, is in framed teak with wainscot oak panels secured in with bilection mouldings, all polished. Two folding push and pull ventilators are arranged over each of the large glass lights admitting fresh air from under outside bonnets, and is carried away by "Torpedo" ventilators fixed in the roof. Sliding doors are provided in all the divisions of the car, those on either side of the vestibule having glass in the centre panel, and there are also fixed glazed lights on each side of these doors, which gives the appearance of there being one long compartment.

Over the tops of the doors and side windows is run a moulded cornice in charrier wood design, all round each compartment, 6 ft. 4½ in. from floor level. Above this cornice the elliptical roof springs, the side covers forming a frieze which is carried over the roof at both ends.

The centre forms one large panel with margin in charrier moulding mitred at corners, the middle portion being filled in with alternate plain and reeded narrow Kauri pine slats, and the whole roof is painted and enamelled white, a very light and airy appearance being thus produced.

The luggage compartment has double folding doors on each side for passengers' luggage, and is painted and grained on sides, with roof white. In the engine compartment the walls and roof are cased with thin steel plates, painted black below the side windows and buff above the sills. Each end of the car is well provided with glass lights, with side ones to drop for ventilation, thus ensuring a good lookout for the driver.

The under-frame is of steel channels and plating throughout, well trussed to

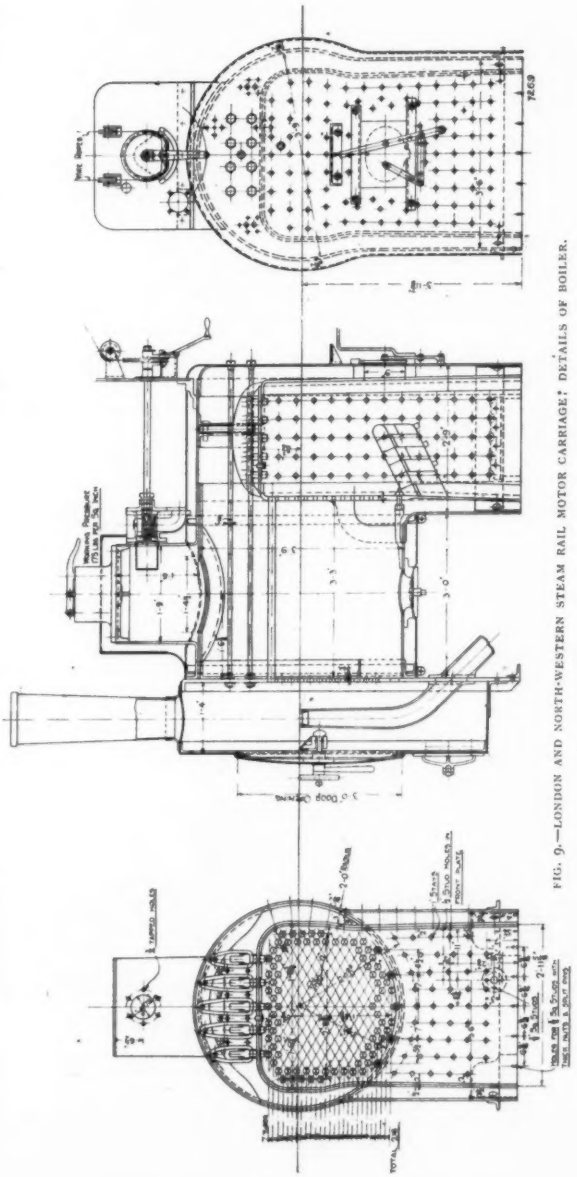


FIG. 9.—LONDON AND NORTH-WESTERN STEAM RAIL MOTOR CARRIAGE: DETAILS OF BOILER.

carry the weight of the accumulators, dynamo, water tank, and vacuum cylinders at the centre. Steps with hand rails are provided at the vestibule entrance doors on each side of the car for use where platforms are not existing. These steps are made to radiate to the side of the car for travelling, and until this is done by the attendant the driver cannot start, the arrangement being that the operation of closing in the steps shuts the brake valve and allows the driver to proceed. The cars are lighted throughout on Stone's system, all the lights being suspended from the centre of the roof. The deck lights and driver's lamps are also fitted electrically, and for petroleum if required. Electric bells are provided, and also speaking tubes at each end of the car, with a code arrangement when driving from either end. The consolidated system of heating is employed in the passenger compartments with long heaters at the sides. Both automatic, vacuum, and hand brakes are fitted, arranged for operation from either end of the vehicle.

The engine is of the locomotive type, with horizontal inside cylinders, 9¼ in. diameter by 15 in. stroke, and loco. type boiler mounted over them; the latter works at a pressure of 175 lbs. per sq. in., and has 317·27 sq. ft. of heating surface and 6·38 sq. ft. grate area; the driving wheels are 3 ft. 9 in. diameter, spaced 8 ft. 6 in. between centres. This is the first instance of an inside cylinder steam rail motor car on a British railway.

The following are the principal dimensions of the car:—

Engine bogie centres	8 ft. 6 in.
Carriage ,, ,, ...	8 ft.
Centres of bogies	37 ft. 9 in.
Wheelbase	46 ft.
Length of car	57 ft
Length over buffers	61 ft.
Height from rail at centre	12 ft. 5½ in.
,, ,, ,, ,, side cornice ...	10 ft. 7½ in.

The body portion and under-frames were designed by Mr. C. A. Park, M.Inst.C.E., and built at Wolverton; whilst the engines were designed by Mr. George Whale, M.Inst.C.E., and built at Crewe. The car weighs 43 tons 8 cwt. with tanks and boiler full, and of this 27 tons 8 cwt. rests upon the engine truck. The total water capacity of the combined tanks is 455 gallons.

Locomotives at the Liège Exhibition.

MR. WM. M. URIE, M.I.Mech.E. of the Locomotive Department, Caledonian Railway, writes as follows:—"In the very interesting paper on 'The Locomotives of the Liège Exhibition,' on page 318, paragraph 3, the author states that the results obtained from one of the Belgian engines, 'La Meuse,' fitted with Schmidt's superheating arrangement, in a trial made between Brussels and Liège, that the engine picks up five minutes over this difficult route, and replaces two of the 'Caledonian' model which have a tractive effort of 13,300 lbs. According to particulars I obtained during a recent visit to the exhibition, I find that the tractive effort of the 'Caledonian' model is given as 10,400 kilogrammes, or say 22,921 lbs., and the tractive effort of 'La Meuse' is 16,850 kilogrammes, or say 37,137 lbs.

"The following particulars will show that the proportions and working steam pressures are vastly different, and that the tractive effort of 'La Meuse' is not equal to two of the 'Caledonian' model, built in Glasgow seven years ago.

	"Caledonian" Model.	"La Meuse."
Cylinders number	2	4
,, diameter	19 ins.	17 ins.
,, stroke	26 ins.	24 ins.
Working pressure, lbs. to sq. in. ...	195	210
Wheels coupled, number	4	6
Heating surface, total sq. ft. ...	1,373	1,494
Fire grate area, ,, ..	22·27	32·38
Weight of engine, working order	53 tons.	76 tons
Theoretical tractive effort	22,921 lbs.	37,137 lbs.

"It may be interesting to your readers to know that the number of locomotives working on the Belgian State Lines built to the 'Caledonian' Model is over 200."

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

The Single-Phase Railway System.

It was not our intention to make any reference to the above system in this issue after the description of the salient features of the most important American and European lines, which appeared in these notes last month, but the paper by Mr. C. F. Scott, of the General Electric Co. (U.S.A.), read to the twenty-fourth annual convention of the American Street Railway Association at Philadelphia, is of interest as setting forth the views of an engineer who has been engaged on single-phase railway work since its inception. The radical difference between railway systems using direct current motors and those using single-phase motors, lies not so much in the car or power house, as in the circuits connecting them. The high voltage used on the trolley wire eliminates the expensive feeders, and also enables the current to be carried to a greater distance from the power house, or from the sub-station. The sub-station necessary for a single-phase system requires merely step-down transformers reducing the pressure of the feeders to that of the trolley wire, and moreover requires no rotating apparatus, while the sub-station for supplying direct current to a railway system must be equipped with step-down transformers and rotary converters. Fewer sub-stations are required for a single-phase system than for a direct current system operating the same number of cars on the same headway, and these do not require as much attention as in direct current systems where the attention given to rotary converters must be skilled, while, of course, this cannot be said of static apparatus. It is these features which render the single-phase system peculiarly adapted to long distance railways.

The single-phase motor is the part which has received most criticism and comment, for it has been recognised that if a satisfactory type can be produced the remaining parts of the system present no difficulty, as they consist in the adaptation of transformers, high tension transmission, and controlling gear, of a more or less standard type, to the purpose. But the motor and car equipment present difficulties not hitherto experienced. Such car equipments must be suitable for hand control in the case of small cars, and multiple unit operation in the case of long trains. In many cases it must be possible to run on alternating or direct current systems without change of apparatus or car equipment. Forms of trolley and overhead construction, suitable to the new conditions of current and voltage and also for high speeds, must be evolved.

It is just a little over three years since Mr. Lamme, in a paper to the American Institute of Electrical Engineers, announced that a commercial single-phase railway motor was an accomplished fact, and since then a high voltage trolley construction has been developed, and proved strong and reliable in actual service under line voltages of 3,300. A sliding contact device which does not require reversing when the direction of the car is changed has been found more satisfactory, especially for high speeds, than the trolley wheel now used on direct current systems. Transformer sub-stations are in satisfactory operation without any attendants. Less than half the controller notches required for direct current are necessary for equally smooth acceleration in the case of alternate current, and the controllers are simpler, as no magnetic blow-out is required. Operation on the direct current systems at present in use is found of considerable value where the alternating current system is extended from an existing direct current system, or where it is found necessary for traffic reasons to run over a direct current system. Although the speed of such alternating current motors is higher than corresponding direct current machines, there have been no bearing troubles, and commutation has proved satisfactory, although the increased current required at low voltages necessitates a brush capacity equivalent to that on a direct current motor of twice the output.

While the direct current motor is essentially a one-speed machine—that is, once it attains a certain speed it continues to run at that speed until there is a change either in the load or the voltage—and the use of series-parallel control merely adds one more speed—approximately half the first speed—to the equipment. The alternating current motor, on the other hand, has no rheostat, hence the voltage applied to the motor, and therefore the speed may be varied economically by connecting any suitable tap from the auto-transformer to the motor, consequently the motor-man can run at any speed with economy, and if there is a tap giving a voltage higher than the normal running voltage, this may be used for giving a higher speed should the driver or motor-man desire to make up lost time.

With regard to the use of high voltages on the trolley wire, safety is largely a question of mechanical excellence, and catenary suspension, as described in our last issue, has been developed to a point where it is superior to the trolley

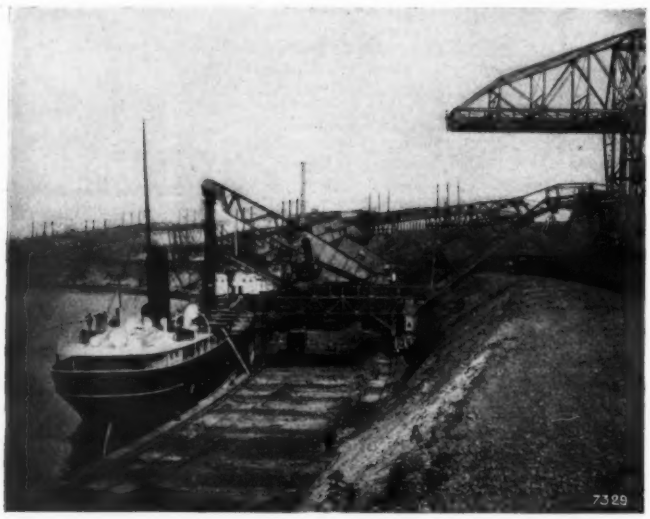


FIG. 1.—GENERAL VIEW OF "HULETT" ORE UNLOADER.

system used with a direct current. As the motors used are wound for 200—250 volts, they are connected two in series on the 500 volt direct current systems over which they run. The control is then rheostatic, and change-over switches are provided to change from one controller to the other. A periodicity of 25 cycles per second has been standardised,* and when the supply is from a power house, which generates at any other periodicity, this must be charged to the proper periodicity by means of motor generators.

The generators may be single, two, or three-phase. In the case of the first of these the supply is quite straightforward. When polyphase supply is available, each phase may be used to supply particular sections of the line. As polyphase generators are somewhat cheaper, this will probably be found advantageous.

Dealing with the field for single-phase railways, Mr. Scott pointed out how that the absence of rotary converters, with their large and expensive sub-stations and staff, and the simplicity of the car equipment reduced capital and operating expenses to a very low figure, rendering profitable lines which, owing to small traffic, could not be made to pay with the large capital expenditure necessary with a direct current system. Another feature which makes the single-phase system stand out ahead of its rivals is trunk line service with its heavy, but infrequent, trains. In such cases the sub-station stands idle for a large part of the time, and if that station is expensive and is manned by an expensive staff, as would be the case with a direct current equipment with rotary convertors, the financial prospects are not particularly bright. If the sub-stations are, say, eight miles apart, each will supply an eight-mile stretch of line, and in order to take power from such a station continuously the trains running at forty miles per hour must run to a twelve-minute headway. If they are an hour apart, as would be more likely, the sub-station would only be in use one-fifth of the time. Trains in each direction would, when passing each other, make enormous

* The author was referring only to the work of his own firm, as there are, especially in Europe, single-phase lines operating with periodicities as low as 15—16 cycles per second, and in at least one case 40 cycles has been used satisfactorily.

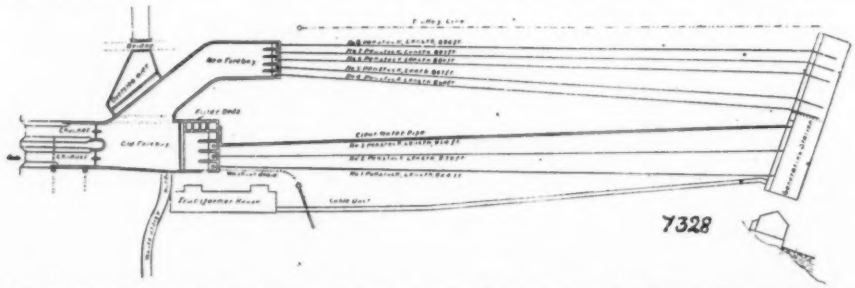


FIG. 2.—RELATIVE LOCATION OF FOREBAY, PIPE LINES, GENERATING STATION, AND STEP UP TRANSFORMER STATION.

demands for a few minutes on the sub-station supplying that particular section, and sufficient plant to cope with such a demand would be necessary. Obviously it is desirable to reduce the number of sub-stations, but this cannot be done with a direct current system, as one is immediately faced with a large increase in the cost of feeders.

A single-phase system, by enabling higher trolley wire pressures to be employed, removes the difficulty of large feeders, and so makes it possible to reduce the number of sub-stations one-half or one-fourth that necessary with direct current, and, as already pointed out, these are much less costly, as they contain only static transformers, hence the field for the operation of single-phase equipments covers rural roads with light traffic, or trunk lines with heavy passenger and freight trains running at fairly wide intervals.

The author subsequently proceeded to outline several successful single-phase lines, but most of those mentioned, and also some European lines, were described in these notes last month.

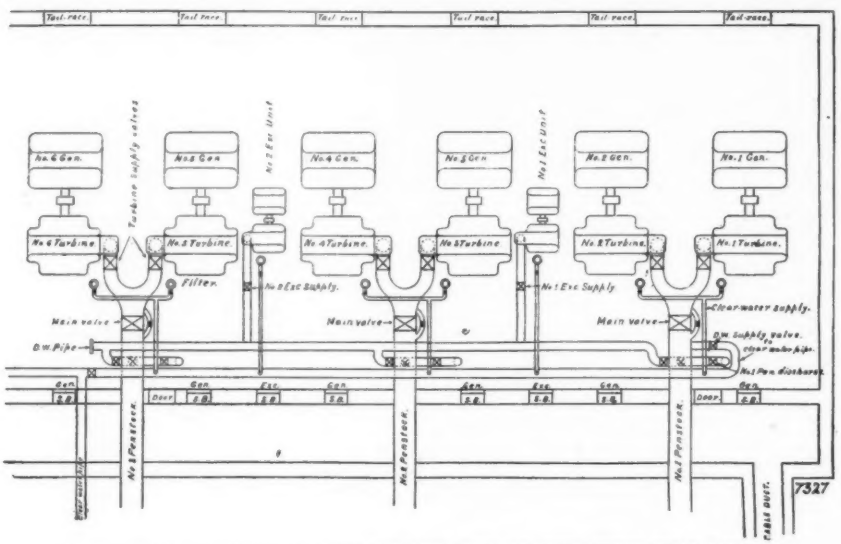


FIG. 3.—GENERAL ARRANGEMENT OF TURBO-GENERATOR UNITS AND PIPING WITHIN THE OLD STATION.

Electrically Operated Iron Ore Unloaders on the Great Lakes.*

THE ore-handling facilities at the National Tube Co.'s† docks, at Lorain, Ohio, is said to be the most complete in any part of the world. The unloader seen in operation on one of the ore-carrying steamers (Fig. 1) has been designed by Mr. G. H. Hulett, third vice-president of the Wellman-Seaver Morgan Co., Cleveland, Ohio, and is one of two just installed. An enormous grab bucket which, when open, has a spread of over eighteen feet, and which automatically digs and lifts from the hold ten tons of ore at each load, is carried at the lower end of the vertical leg, which, as will be seen, is suspended from a long pivoted walking beam, the latter being carried on a carriage or trolley which travels backward and forward on the girders. The operator, who controls all the motions of the bucket, rides at the lower end of the leg, directly above the bucket. He is enabled to effect this control with ease and certainty, as he operates a master controller, which closes the circuit of magnetically controlled switches, at or near the motors, the method of control being somewhat similar to that which enables the driver of an electric train to start and stop the motors fixed at the middle or rear of the train by means of his small master controller. The hoisting mechanism causes the walking beam to oscillate up and down, carrying the bucket down into the hold of the ship and up again. The leg and bucket may also be made to rotate on trunnions at the top of the former, close by the end of the walking beam, so that the bucket itself can reach out in all directions. The trolley on which the walking beam is mounted,

* *The Electrical Review*, N. Y., October 7th.
† A branch of the United States Steel Corporation.

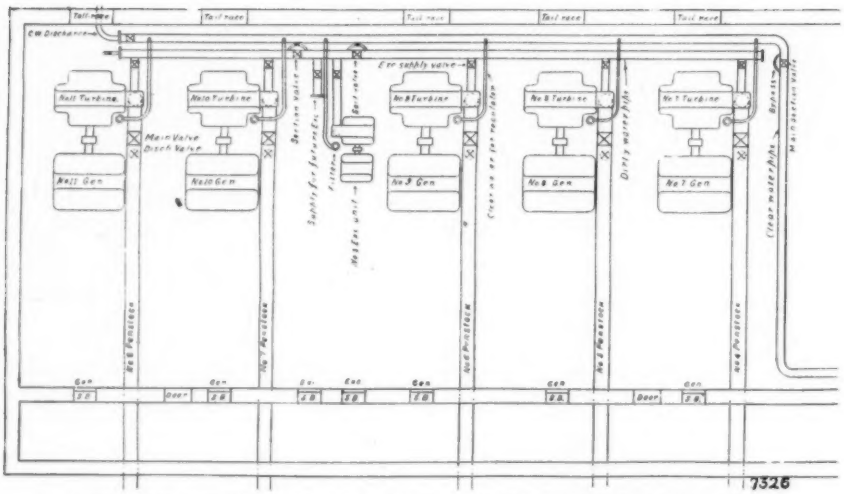


FIG. 4.—GENERAL ARRANGEMENT OF TURBO-GENERATING UNITS AND PIPING WITHIN THE NEW STATION

carries it and the vertical leg backward and forward, so that the bucket may discharge into hoppers which are mounted between the supporting girders; these hoppers, in turn, discharge into an auxiliary bucket car which travels on the cantilever extensions seen on the right, and automatically dumps the ore at any desired point, returning at once to its position under the hoppers. The control of the buckets carrying a load of ten tons is a matter of some importance. When it is desired to stop the load, resistance is first automatically introduced in series with the motor which slows it down; the motor is then reversed and acts as a generator, sending its current into the resistances.

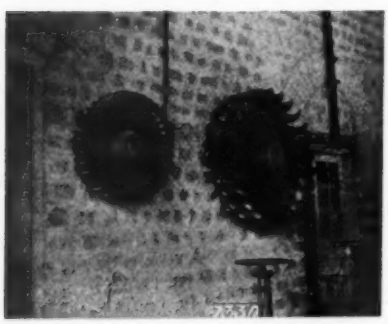


FIG. 5.—VIEW OF THE ROTATING MEMBERS OF THE 1,250 H.-P. TURBINE AND THE SMALL EXCITER TURBINE.

The value of using the reversed motor as a brake is that its retarding effect is greatest the greater the speed, hence it is valuable in bringing a heavy load to rest without shock; finally the band brakes are applied, which stops the load entirely. The band brakes also act automatically in case of a failure of the current.

Electric Power for Industrial Purposes in India.*

THE Cauvery power plant in the province of Mysore was started for the purpose of supplying power to the Kolar gold-fields, some ninety-two miles distant, and as the available head is about 400 ft., giving 200,000 h.-p. during the rainy season, falling to 12,000 h.-p. in the dry season, the prospects before the undertaking may be considered satisfactory as Pelton wheels can be employed with a high turbine and generator speed, economising capital on both these items. The first section of 4,300 kilowatts was started up in 1902, and an extension of 3,600 kilowatts has just been completed, making a total of 7,900 kilowatts or about 10,500 h.-p. The river divides into two branches about a quarter of a mile above the intake, and two low-level masonry dams divert all the water in the river into the canals leading to the power station during the dry season. The power station is about one and three-quarter miles below the intake channels, but the canal which conveys the water to

* *The Electrical Review*, N. Y., October 14th, 1905.

the power house is over three miles long, as it follows the contour of the country. Where this channel passes through rock, the gradient is 3 in 5,000, and in earth, 1 in 5,000. The two channels, or canals, end in a forebay (Fig. 2), which has recently been extended as shown. From these, pipe lines extend to the power house as indicated on the plan. The power station is divided into the old and the new generator rooms: the arrangement of each being shown in Figs. 3 and 4. The turbines are by Messrs. Escher-Wyss & Co. giving 1,250 b.h.-p., at 300 revolutions per minute; they are coupled to 720 kilowatt rotating field three-phase 25 cycle 2,200 volt alternators by the General Electric Co., U.S.A. It will be seen that in the old power station one pipe serves two turbines; the three pipes shown varying from 39 to 45 ins. in diameter, while in the case of the new penstocks, these are from 27 to 36 ins. in diameter, and there is one for each turbine. Each of the penstocks have two expansion joints, allowing about 5 ins. expansion, in each pipe line. All the pipes are of steel, ¼ to ½ in. thick, and were made by Messrs. Mechan & Sons, Glasgow.

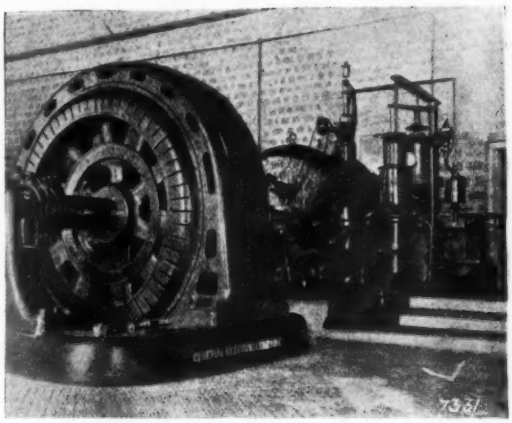


FIG. 6.—1,250 H.-P., 720 KILOWATT, TURBO-GENERATOR UNIT.

In addition to the large generators, there are three 125 h.-p. exciter sets also driven by Pelton wheels. An excellent idea of the relative size of the bucket wheels of these will be obtained from Fig. 5, the larger of which shows the 1,250 h.-p. bucket wheel, and the smaller the 125 h.-p. wheel. The larger wheel is 5 ft. in diameter, has twenty-four buckets on its periphery, and is cast solid with the buckets. Two nozzles supply water to each wheel. The small wheel is 3 ft. in diameter, and has thirty-six buckets. In the plan of the pipe line (Fig. 2) will be seen a clear water pipe. This is filtered water for the purpose of operating the hydraulic governors which are direct connected to the wheels, and as this part of the equipment should be exposed to as little wear as possible, it has been deemed advisable to filter the water supply used for operating them, though, should the clear water supply fail, water from the penstock can be immediately turned on.

The hydraulic governors act as follows. A variation of the load on the turbine tends to alter the speed of the wheel, from the shaft of which is driven by chain gear, a centrifugal governor working against a stiff spring; the movement of the governor moves a small governor rod which controls a small valve. This valve is kept constantly in motion by very slight changes in load which tend to destroy the equilibrium of the valve. So long as the speed remains constant, the water pressure on both sides of the valve is the same, but a small change produces a slight up and down motion of the control valve which produces a relatively greater movement of the larger hydraulic piston, which deflects the nozzle playing on the wheel. One of the units is shown (Fig 6), the hydraulic governor being seen close against the turbine.

The 2,200 volt cables from the generator are carried up the cable duct (see Fig. 2) to the transformer house, where the pressure is raised to 35,000 volts, and transmitted over duplicate three-phase transmission lines to the Kolar gold-fields, ninety-two miles distant. A separate 35,000 volt line goes to the city of Bangalore, which has 180,000 inhabitants, and is sixty miles distant.

Notes from the Foreign Press.

By Dr. ALFRED GRADENWITZ.

A Removable Propeller for Freight Barges.

A REMOVABLE propeller for freight barges, the invention of J. Ambroise Farcot, is described in No. 10 of *La Locomotion Automobile*.

A trial apparatus fitted to a 500 tons "Seine" barge consists mainly of an iron tube frame supporting in front a 3½ h.-p. vertical "Buchet" motor with water circulation, and behind two paddle wheels mounted on a single axle, the latter being driven by the motor through a chain drive.

The water pump is simple in construction and is controlled directly by the motor. It is able to draw in under a head of 3 m. the cooling water which is discharged into the river. The change gear controlled through a double "Oldham" joint, consists of two friction clutches acted on by a rod, the end of which is controlled by the driver.

Ball-bearings have been provided throughout, even in connection with the paddle wheels.

The depth of immersion of the paddles is capable of instantaneous regulation according to the shape of the boat and the character of the current, so as to utilise to best advantage the output of the motor.

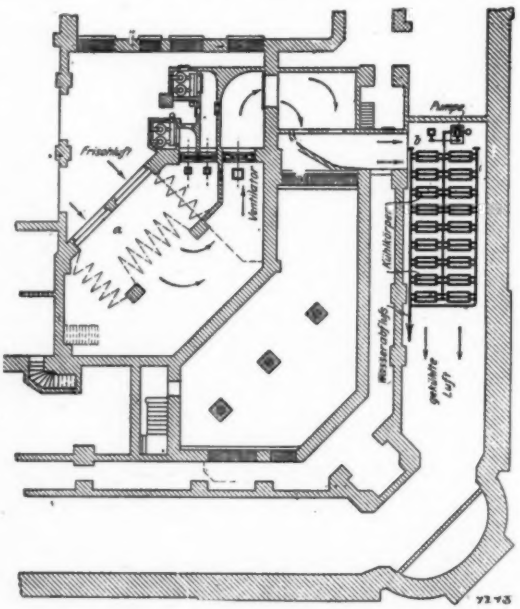
The tube-frame, mounted on a pivot, is continued in front by a horizontal rod, the end of which is handled by the driver. By shifting this rod either to the left or right, the whole apparatus is turned round, thus altering the resulting force of the paddles. This steering effect is obtained quite readily, so as to insure an extremely easy control of the motor-boat.

The following advantages are claimed for this removable propeller: Its simplicity of construction, ease of manipulation and low cost, nearly instantaneous mounting and unmounting, an excellent efficiency due to the arrangement of the paddles and the ready adjustment of their immersion. On account of its small draught, the propeller may be fitted to any kind of boats even in shallow waters.

Air Cooling Plant.

FOLLOWING the practice which has been followed for a number of years in the United States, air cooling plants are now being adopted in Germany in connection with office and private buildings, theatres, &c. The accompanying figure is taken from a recent issue of the *Zeitschrift des Vereins deutscher Ingenieure* and represents one of the three air-cooling plants which have recently been installed in the building of the German Bank, Berlin.

The refrigerating agent is water, derived from a special well at a temperature of 12°. The air to be cooled first enters the dust chamber *a*, where the larger part of the dust carried along drops to the ground owing to its gravity, while the finer dust is kept back by wool filters. The air is next thrown by an electrically driven fan into the compartment *b*, where thirty-six cast-iron refrigerators have been installed. The refrigerators having each a surface of 20 sq. m. are supplied with water from the well by a centrifugal pump of 350 liters capacity per minute, which is coupled to a 2½ h.-p. motor. The air streaming past the refrigerators is thus cooled and freed



AIR COOLING PLANT.

from its moisture while the water traversing the refrigerators having been warmed, is discharged into the drainage conduit.

The plant is mainly operated during the hot hours of the day, while it is quite sufficient by night to introduce the cold external air without any special cooling.

The blower supplies 600 cub. m. per minute with a pressure of 10 mm. water column and a speed of 400 revolutions per minute. A 4 h.-p. motor, the speed of which can be adjusted between 400 and 200 turns, is used to drive the blower.

The cost of operation, accounting only for the electrical energy used for the blower and centrifugal pump is 1·3 marks per hour.

Experimental Electrical Operation on the Vienna Metropolitan Railway.

An experimental electrical service on a system which has so far been employed only in some exceptional cases, is to be organised on the Praterstern-Central Custom-House line of the Vienna Metropolitan Railway, the current being supplied by a direct current three-conductor line, the middle conductor of which is constituted by the railway rails, while the two bare external conductors are laid out on poles.

The pressure between the two external conductors is to be 2 × 1,500 volts, which direct current tension has not so far been used in connection with railway operation. While so high figures would not be required for this short experimental line, 1·4 k.m. in length, the intention of the contractors, Messrs. Fr. Krizik, of Prague, has been to show that this high tension does not involve any danger. The motors are connected either all in series or by pairs in parallel and in series to the external conductors, whereas the centres of the motor sets are connected to the truck, i.e. to the railway rails. The two external conductors constituting the two sides of the three-conductor system are accordingly loaded equally at any time, the railway rails thus being as a rule practically free from any current, which is of the highest importance. The rails and the metal parts of the locomotives or cars which are connected to the latter, are in fact always at a tension equal to zero, the pressure of 3,000 volts obtaining only between the two external conductors.

The electrical energy is supplied as three-phase current at 5,000 volts pressure, and is transformed into direct current of the tension referred to above.

The trolley-wires have an octagonal cross-section of 115 sq. mm. surface, and are so arranged as to lie vertically above each railway rail, thus being protected against the smoke and exhaust of the steam locomotives running on the same line. The wires are placed at a distance of 5·2 m. from the upper edge of the rails.

Electric locomotives have been chosen in connection with this experimental service, so as to dispense with any conversion of the existing cars. These locomotives are fitted with four motors of 200 h.-p. each, the maximum current intensity absorbed by the motors being 200 amp. The current is supplied from two current collectors of parallelogram shape arranged on both sides and which are pressed against the conductors by substantial springs. Only the lever of the controller is accessible to the guard of the locomotive. Pneumatic brakes are used throughout.

It may be mentioned that the tension of 2 × 1,500 volts is used only on the open road where higher speeds are employed, while at the stations above mentioned the motors are connected between one external conductor and the zero conductor, reducing the tension to 1,500 volts.

The experimental service is to be carried out by night after the regular service has come to an end.

A Fireless Locomotive.

The fireless locomotive system dispenses with the firebox used in ordinary locomotives by utilising the heat capacity of the water. The boiler consists of an ordinary water reservoir to the water in which is imparted heat sufficient to raise the steam required for the operation of the locomotive, by leading steam from a stationary boiler into the reservoir at a pressure greater than that required in the latter.

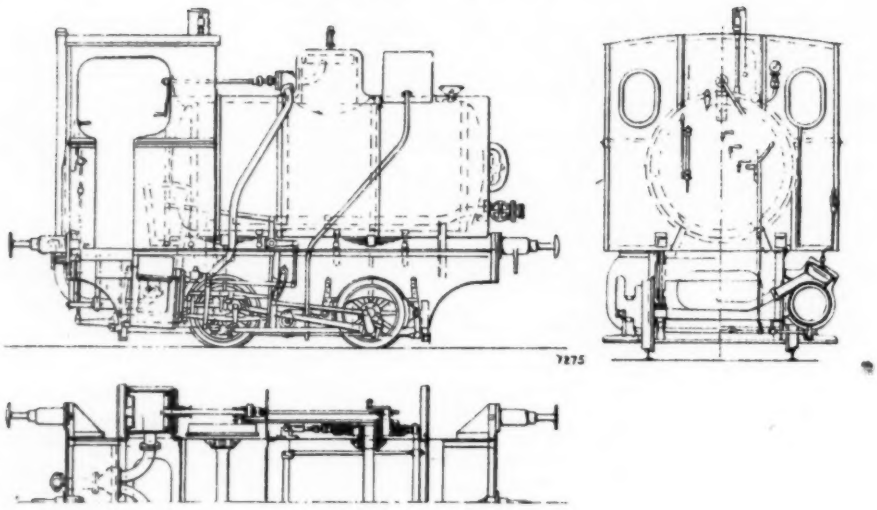
As the boiling point of a liquid increases as the pressure becomes greater, the temperature of the water will depend mainly on the resistance of the boiler.

In the case of a locomotive described in a recent issue of *Die Lokomotive*, the boiler is fed from a stationary plant at 8 atmospheres superpressure, while being designed for a pressure of 10 atmospheres. In the same proportion as the pressure in the reservoir decreases as a consequence of the disappearance of steam above the water surface and the cooling of the water due to the influence of the external temperature, fresh steam will be formed of ever decreasing tension. The fireless locomotive is therefore fitted with relatively large steam cylinders, so as to be able to exert a high pull even with the lowest pressure in the boiler.

The working of the locomotive itself is identical to that of any other locomotive, while the operation is advantageous, requiring only the services of one man, any danger of explosion being avoided and the necessity of stoking being dispensed with.

The following are the main dimensions of the locomotive :—

Diameter of cylinder	400 mm.
Stroke of piston	350 ,,
Wheel-diameter	700 ,,
Distance of axles	1,500 ,,
Steam pressure	10 atm.
Boiler water	3,750 .
Weight empty, about	10·8 t.
Weight in working order, about ...	14·3 t.



FIRELESS LOCOMOTIVE.

Effects of Hot Riveting on Metals.

In a memoir recently read before the French Academy of Sciences M. Frémont records some experiments made with a view to elucidate any alterations taking place in the quality of a metal after having been used in connection with hot riveting.

Seven different metals corresponding to the usual conditions of industrial practice were chosen, viz., Swedish iron of a breaking strength of 33 kg. per sq. mm. and six steels of different strengths, varying between 35 and 55 kg. per sq. mm. From each of the seven specimens three pieces were derived to be submitted to the various mechanical tests, viz., tension and bending, both statical and dynamical. One of these pieces was tried in the primitive condition, *i.e.*, before undergoing any thermal or mechanical treatment. Another piece was heated in the forge to the usual temperature of riveting, viz., about 900°—1,000°, without, however, being submitted to any mechanical treatment. A third piece was finally used for a rivet applied in the hot state under a pressure of 25 tons and unriveted completely, in order to be submitted to the same tests as the other pieces.

From the opposite table it will be seen that the metal is improved considerably after undergoing the mechanical contraction, due to cooling under tension, attending the riveting work.

The results of impact tests on notched bars show the brittleness not to have increased; the increase in strength is thus due to a tempering effect, as might be supposed.

M. Charpy presents to the same Academy a memoir wherein it is pointed out that M. Frémont's results might be interpreted as showing

Kind of Metal.		Tension Tests.			Impact Tests. Live resistance. kg.
		True Elastic Limit. kg.	Breaking Resistance. kg.	Torsion. $\frac{S-S1}{S}$.	
Swedish iron	primitive	16·45	33·60	0·55	17
	heated	16·45	33·60	0·49	19
	unriveted	26·00	43·40	0·54	18
Mild steel (marine steel)	primitive	19·50	35·70	0·65	22
	heated	16·85	35·00	0·63	26
	unriveted	26·00	43·40	0·66	24
Mild steel (structural steel)	primitive	23·10	45·50	0·62	6
	heated	24·00	42·70	0·61	2
	unriveted	34·55	55·30	0·59	10
Nickel steel 3 per cent.	primitive	27·50	44·10	0·63	22
	heated	22·50	42·00	0·65	19
	unriveted	40·00	57·40	0·62	27
Half - hard steel (marine steel)	primitive	24·50	49·00	0·57	6
	heated	22·50	48·30	0·59	5
	unriveted	40·00	65·00	0·59	8
Nickel steel 5 per cent.	primitive	30·00	49·70	0·66	23
	heated	31·65	49·70	0·64	22
	unriveted	53·20	72·80	0·64	29
Half - hard steel (German)	primitive	30·00	54·00	0·64	10
	heated	29·00	56·00	0·65	10
	unriveted	36·75	63·70	0·61	22

an improvement takes place in the quality of the iron or steel used in riveting, after the rivets have been put in the hot state. This improvement, however, takes place only in the

event of the initial quality of the iron or steel being defective, or at least appreciably inferior to the quality it might acquire after a rational treatment. As regards, for instance, mild steel, this is known to attain its best qualities after a sudden cooling from a high temperature, its tensile strength being slightly increased, while its brittleness is reduced considerably. After being annealed at relatively low temperatures, or by a slow cooling from a high temperature, the metal will, however, have a minimum tensile strength, while its brittleness may attain very high figures. The live resistance opposed to shocks by notched bars may thus be varied for the same metal in a ratio of 10—40 and more, according to the thermal treatment it is submitted to.

In the case of riveting work the conditions of the thermal treatment undergone by the metal are determined completely by the conditions of the work to be performed, these conditions being conducive to qualities superior to those obtained by a prolonged annealing at a higher or lower temperature or after a heating followed up by a slow cooling. The qualities will, however, be considerably inferior to those that would be obtained by heating the metal rapidly to a high temperature in order afterwards to cool it suddenly.

The author, therefore, thinks that either an improvement or a deterioration will be obtained in the qualities of the metal, according to its initial condition.

Power Transmission by Electricity and Blast Furnace Gases.

CONSTANT endeavours are being made by mining engineers to utilise blast furnace gases in a more economical way than has heretofore been possible, e.g., by transmitting them to great distances, with a view to utilise them for heating and power purposes.

At a recent meeting of the Association of German Engineers, M. Randel (see *Zeitschrift für Elektrotechnik*, No. 41) discussed a power transmission of 1,000 h.-p. to a distance of 4 km., either by means of gas conduits or electrical energy, illustrating the suitability of the former process of power transmission.

The blast furnace gas is to yield 1,000 heat units per cub. m. In the case of electrical power transmission the capacity of the gas motor would have to be made greater, so as to cope with the loss in transmission, which amounts to about 17 per cent. of the primary power, or 20 per cent. of the secondary power. Instead of 1,000 h.-p., the engine would accordingly have to give an output of 1,200 h.-p., and using a rotary current dynamo of this capacity a rotary current motor of 1,000 h.-p. would be required, in addition to a three-conductor circuit 400 m. in length and 35 sq. mm. in cross-section, and a switchboard.

In the case of gas power transmission the output of the motor would not have to be altered in any way, while a gas conduit 4,000 m. in length would be required, as well as a device for overcoming the resistance opposed to the gas by the conduit. This resistance may be dealt with either by suction or pressure.

In order not to excessively increase the diameter of the conduits, a rather considerable resistance should be allowed for, and the author supposes the limit of resistance to be 1 m. water column, which could be overcome by ordinary fans. A suction outfit seems to be suitable in connection with small lines, there being no objectionable effects due to the in-drawn air. In the case of long conduits laid underground, there is a greater risk of leakage, resulting in air being mixed to the gas in greater or less amounts, reducing the amount of gas actually drawn in by the pump, while decreasing by the same amount the output of the engine. In the case of very considerable additions of air there may be formed a mixture susceptible of separating, and which, in the case of accidental ignition, might result in serious damage. In such cases a pressure plant would be preferable. In the case of a suction device in connection with short conduits there is no necessity of a special machine plant, the gas pump of a double-acting two-cycle engine overcoming by itself the resistance without interfering with the efficiency of the engine to any considerable extent.

In the case of a pressure outfit with extensive conduits, a high pressure fan should be provided for, as the safety of operation and avoidance of trouble in the case of a standstill of the engine will thus be best warranted, while the additional expense for a larger driving motor would be outbalanced by the additional cost of a cylinder blower.

In the present case, the conduit being only 4,000 m. in length, a pressure device would be preferable. Now, a pressure loss of 1 m. water column with a 4,000 m. conduit and 3,300 cub. m. gas of a specific weight = 1 (as reduced to air) would require pipes 400 mm. in diameter. The following outfit would accordingly have to be provided for:

	(Austrian Kronen.)
Gas pipes, 4,000 mm. in length and 400 mm. in diameter, per meter ...	103,500
1 Gas-motor of 50 h.-p. for the ventilator	11,300
1 High-pressure vane ventilator for 60 cubic mm. per minute	1,600
Belts, conduit, cost of erecting and connections	3,400
1 Regulating bell	700
Foundations and bolts	450
Total	K. 120,950

In the case of electrical transmission the following would be required:

An additional 200 h.-p. in the capacity of the engine	27,600
1 Rotary current primary engine of 1,200 h.-p. with exciting machine	30,000

	(Austrian Kronen.)
1 Secondary rotary current motor for 1,000 h.-p., with starter	40,000
Rotary current line, 4,000 m. in length, each conductor being 35 sq. m. in cross-section, laid out on poles ...	11,500
1 Switchboard, with accessories ...	2,300
Miscellaneous, foundations, &c. ...	5,750
Total	K. 117,150

The cost of transporting the material is not accounted for. The cost of operation would be as follows:

1. *In the case of gas power transmission:*

	(Austrian Kronen.)
Interest on invested capital (5 per cent. on K. 120,950)	6,050
Amortisation and upkeep of conduit (4 per cent. on K. 103,500)	4,140
Amortisation and upkeep of motors, ventilators, &c. (7·5 per cent. on K. 12,900)	970
Guard, lubricating material, polishing material, water	2,200
Gas consumption, 150 cub. m. per hour (·28 K. per hour) in 5,400 hours	1,510
Gas losses (10 per cent. on 3,000 cub. m. = 300 cub. m. per hour) at 0·55 K. per hour, in 5,400 hours	2,970
Total	K. 17,840

2. *In the case of electrical power transmission:*

	(Austrian Kronen.)
Interest on invested capital (5 per cent. on K. 117,150)	5,860
Amortisation and upkeep at 5 per cent.	5,860
Guard, lubricating material and polishing material (K. 3·50 per day) ...	1,270
Gas consumption for 200 h.-p. at 3,000 heat units per hour = 600,000 heat units = 600 cub. m. per hour at 0·190 Heller per 1,000 heat units = K. 1·15 per hour, amounts yearly, with 5,400 working hours, to ...	6,210
Total	K. 19,200

From the above the interesting fact is inferred that the conditions of the case, the cost of power transmission by either electricity or gas would be about the same, both as regards the invested capital and cost of operation. In the case of smaller lengths of line the gas transmission, and with greater lengths electrical power transmission would be more suitable. A difference in local conditions would no doubt alter the results of the above calculations.

Considering that the available blast furnace gas has only about the 1,000 heat units per cub. m., while power gas contains an additional 25-30 per cent. heat units, equality of the two methods would be obtained only for 5 km. length in the case of power gas.

Trolley Wire Holder.

THE accompanying illustration is that of a trolley wire holder which forms one of the specialties of the Spherical Metallic Packing Co., of Harphurhey, Manchester. The apparatus, which is suspended by means of the usual insulation stud, consists of a pair of bronze plates articulated between their upper and lower edges, which are respectively shaped to form pairs of jaws. The lower jaws are shaped to seize and hold more than a semi-circumference of the trolley-wire. The upper jaws are fitted with means for suspending the holder, and at the same time for holding the jaws firmly apart, so that they cannot approach while in use. It will be seen that from the intermediate articulation or jointing together of the plates while the upper pair of jaws are held or forced apart the lower pair will be held upon the trolley wire. The grip is automatic, and increases directly as the weight of the wire and as the thrust of the trolley-wheel. Solder, of course, is dispensed with, and by its use it is claimed that the trolley-wheel does not leave the wire at the points of support, thus eliminating sparking.

By PERCY LONGMUIR,
Carnegie Research Medallist.

Foundry Practice.

Slagging a Cupola.—Whilst much attention has been given to mixing pig irons by analysis comparatively little thought has been expended on the question of cupola slags. Hence Mr. D. Rogers, who discusses this question in a recent issue of *The Foundry*, enters a practically virgin field on the scientific side of iron founding. As an example the writer selects a coke containing 10 per cent. of ash, the analysis of the ash being as follows :—

Fe_2O_3	Al_2O_3	Ca O	Mg O	$Si O_2$	S.
0·28	4·4	0·2	0·1	4·8	1·0

The limestone used as a flux has the following analysis :—

Ca O	Mg O	$C O_2$	$Si O_2$	Al_2O_3	Fe_2O_3
49·75	2·08	41·20	5·17	0·69	0·83

The behaviour of cupola slags and a consideration of the comparatively low temperature attainable in the cupola indicates that their composition is approximately that of a subsilicate. The first step lies in ascertaining to what extent the ash of the coke is self-fluxing. Calculating from the molecular weights in the proportion suitable to form a subsilicate, the following results are obtained :—

Formula.		Molecular Weights.		Bases.		
$4\ Fe_2O_3 + 3\ Si O_2$	=	640 : 180	::	0·28 : x	=	0·07
$4\ Al_2O_3 + 3\ Si O_2$	=	411 : 180	::	4·4 : x	=	1·92
$4\ Ca O + Si O_2$	=	224 : 60	::	0·2 : x	=	0·05
$4\ Mg O + Si O_2$	=	160 : 60	::	0·1 : x	=	0·03
						2·07

That is 2·07 per cent. of the silica present in the ash is fluxed by the bases present in the ash. Deducting this from the actual amount of silica present (4·8—2·07) = 2·73 per cent. to be fluxed by lime.

This gives the following equation :—

$$Si O_2 + 4\ Ca O = 60 : 224 :: 2{\cdot}73 : x = 10{\cdot}19$$

That is 10·19 per cent. lime is required to flux the remaining 2·73 per cent. silica. Allowing for desulphurisation on the basis of S + Ca O., the equation is

$$32 : 56 :: 1 : x = 1{\cdot}75$$

thus bringing the amount of lime up to 11·94 per cent.

It will have been noted that the limestone is not pure, hence it is necessary to determine the available lime, which in turn involves a recognition of the silica present. The following table covers these requirements :—

Formula.		Molecular Weights.		Bases other than lime.		
$4\ Mg O + Si O_2$	=	160 : 60	::	2·08 : x	=	0·81
$4\ Al_2O_3 + 3\ Si O_2$	=	411·2 : 180	::	0·69 : x	=	0·03
$4\ Fe_2O_3 + 3\ Si O_2$	=	640 : 180	::	0·83 : x	=	0·23
Silica fluxed by bases other than Ca O					=	1·07

Therefore leaving (5·17—1·07) 4·1 per cent. silica to be fluxed by the lime of the limestone, calculating as before :—

$$Si O_2 + 4\ Ca\ 4\ Ca O = 60 : 224 :: 4{\cdot}1 : x = 15{\cdot}3.$$

Thus the effective lime in a limestone of the analysis given is 34·45 per cent. It has been shown that 11·94 per cent. of lime is required for fluxing, therefore the amount of limestone required is—

$$34{\cdot}45 : 100 :: 11.94 : x = 34{\cdot}65 \text{ per cent.}$$

In the example given each 100 lbs. of coke requires 34·65 lbs. of limestone, and it may be noted that this example does not allow for sand adhering to the pig iron and scrap charged into the cupola.

Gating Malleable Castings.—Malleable founders are only too familiar with the shrinkage and cracking of white iron castings, an evil which is intensified as the section of the castings becomes more unequal. Dealing with gates as a remedy for this evil, Mr. J. P. Fermal* discusses generalities, and his advice may be condensed into :—"Gate an intricate casting in the thinnest part in order that the metal before reaching the heavier part may be somewhat cooled." In many cases the writer finds this remedy more effective than chilling the heavy portions. In gating castings to overcome shrinkage the most successful plan is to feed the heavier parts through the lighter parts at a point as close as possible to the heavy part. For blank gears from 4 ins. diameter and 3 ins. face upwards, the best plan is to cut a feeder

* *The Foundry*, October, 1905

on the periphery and run the metal into the casting through the feeder. Whenever possible it is better to cut a feeder at the side of the casting rather than to place a feeder directly on the casting. Finally hot iron is advised for the production of clean and sound castings.

*Steel Castings and the Constitution of Steel.**—The influence of composition is noted and an average to meet the usual requirements is found in carbon, 0·3 per cent., manganese 0·08 to 1·0 per cent., silicon 0·2 per cent., with sulphur and phosphorous as much below 0·8 per cent. as possible. The deleterious effect of sulphur is shown by quoting a casting containing 0·15 per cent., which gave an elongation of only 4·1 per cent. The neutralising effect of manganese on sulphur is indicated and the sulphide of manganese shown to be less harmful than the sulphide of iron. The effect of carbon is shown by a series of tensile tests in which as the carbon rises extensibility falls and maximum stress increases. The final properties of steel castings are determined by the annealing given, and to be successful this involves both time and temperature. The object of annealing is two-fold, involving structural rearrangement and the relieving of internal strains due to inequalities in the section of the casting. A steel casting unrelieved of its contraction strains is a source of danger, and given the right conditions the casting will fly. For castings of from 0·3 to 0·5 per cent. carbon a suitable annealing temperature is found between 900 and 950° C., and a suitable time at this temperature is found in three days.

Steel: its Properties and Treatment.

Manganese in Iron and Steel.—Mr. A. A. Read records in a recent issue of *Engineering* a comparison of results obtained by different methods of estimating manganese in steel. The gravimetric method employed was the well-known acetate separation, whilst the two volumetric methods employed were the Ford and Williams and the Bismuthate process. Without entering into details of these methods or of the results obtained, we may briefly note the conclusions drawn by the writer. Thus the volumetric results show slightly lower values than those obtained by the gravimetric method, but they are sufficiently near for practical purposes. In the case of ferro manganese the bismuthate gives a rather low result compared with the acetate separation. The chief value of volumetric processes lies in obtaining practically accurate results in a very short time, hence they are preferred by analysts, but when time permits it is safer to use a gravimetric method, because the weighed precipitate can be carefully analysed and checked.

Action of Acids on Iron and the use of the Acid Pickle.†—Professor Burgess reviews at length the action of acids on iron and variations in pickling practice. Practically the pickler has his choice limited to hydrochloric and sulphuric acids, the latter being the most largely used. Both acids offer a wide range of densities and purities. Cost is to some extent influenced by locality, as a rule sulphuric acid being the cheaper. As regards dissolving power one pound of commercial hydrochloric acid as compared with sulphuric acid gives a ratio of about 10 to 19. Practice shows that hydrochloric acid can be used in a higher degree of dilution than sulphuric acid, and this constitutes a marked advantage in its favour. Whilst many authorities have stated the suitable strength of various pickling solutions, comparatively few have given the degree to which they may be exhausted. This is an important factor in calculating for acid consumption, and one upon which further information is very desirable. To increase the percentage consumption of the acid the freshly prepared solution should be as concentrated as is possible and compatible with vigorous and effective corrosion, for in this manner the percentage of acid lost in the waste liquor bears its smallest ratio to the total amount of acid employed. A limitation is, however, found in the density available by the solubility of the iron salts which are formed, since if this reaches the saturation point the action of the acid is greatly diminished or ceases, this being due to the formation of insoluble iron salts on the surface of the metal. As chlorides of iron are more soluble than sulphates, hydrochloric acid may have a higher concentration. Heating the pickling solution enables the acid to be used more efficiently and effects a saving in the size of plant required, but is not always employed owing to the difficulty in constructing the necessary plant. One of the best methods of heating is found in injecting steam directly into the solution, but this is not always permissible owing to the diluting effect of the condensed steam. Owing to the many difficulties met with in acid pickling a tendency is found to replace acid cleaning by that of sand blasting. In this case labour costs are greater, but with anticipated improvement in operation it is likely to become a pronounced competitor of chemical methods. Finally, the absorption of hydrogen by iron is noted. To some extent the hydrogen liberated when an iron article is pickled is absorbed by the iron and this constitutes another of the difficulties attendant on successful pickling. Iron or steel wire of high grade may be rendered so brittle by a few moments' immersion in an acid solution as to become worthless, and on account of this "rotting" it is impracticable to pickle certain grades of iron. The results of an investigation of this problem are promised in a future article.

*Seventh Report to the Alloys Research Committee on the properties of a series of Iron—Nickel—Manganese—Carbon Alloys.** This report, covering

* P. Longmuir, *The Foundry*, October, 1905.

† *Electro-Chemical Metallurgical Industry*, September and October.

* Institution of Mechanical Engineers. Dr. H. C. H. Carpenter, Mr. R. A. Hadfield, and Mr. Percy Longmuir.

103 pages, is devoted to an examination of the properties of a series of steels of ascending nickel content containing an average of 0·44 per cent. carbon and 0·88 per cent. manganese. This subject is one to which considerable attention has been given in the past, and the earlier work of Hadfield, Rudeloff and Guillet is indicated. In particular, Guillet has investigated three series of nickel steels, nickel in each series ranging up to 30 per cent. with an average carbon content in the first series of 0·12 per cent., in the second 0·22 per cent., and in the third 0·82 per cent.

Turning to the experimental work of the present report the chief results obtained are embodied in the appended summary table in which are also included the contents of carbon, nickel and manganese. All the tests represent steels in the forged normalised condition, *i.e.* heated to 800° C. and cooled down with the muffle.

Both tensile and bending tests show that the series of steels may be roughly divided into two groups, one including ductile and the other brittle steels. Up to 4¼ per cent. nickel ductility is fairly high; 4·95 per cent. nickel marks an accession of brittleness, whilst 15·98 per cent. nickel denotes the return of ductility. Tensile results obtained from the steels as cast are embodied in the following table, the condition as in the case of forged steels being that of normalised, *i.e.*, all heated to 800° C. and cooled down with the muffle.

These results follow generally the same order as those of the forged steels, maximum tensile strength, however, being represented at a content of 7·95 per cent. nickel. Singularly enough the maximum is associated with an elongation of 4½ per cent., and the three steels, which, in the forged state, are distinctly brittle, show in the cast normalised state elongations of 6·2 per cent., 4·5 per cent., and 6·2 per cent. The mass resistivities are included in the first table, from which it will be seen that the resistivity rises with ascending nickel. Magnetic tests were made by means of an Ewing

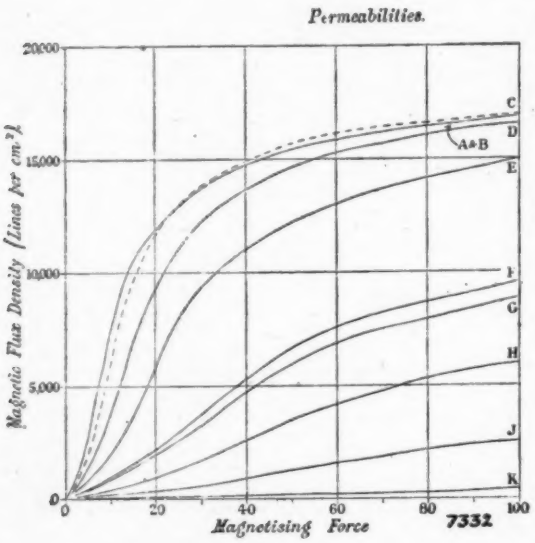
TABLE.—PROPERTIES OF THE SERIES OF ALLOYS, CONDITION OF MATERIAL FORGED AND COOLED FROM 800°C.

Ni. Alloy.	Analyses. Ni.	C.	Mn.	Bending Test.	Tensile Tests. Yield Point.	Max. Stress.	Elongation on 2 inches.	Reduction of Area per cent.	Torsion Tests. Twisting Moment.	Angle of Twist at Fracture.	Compression at 100 tons per sq. in.	Modulus of Elasticity.	Shock Tests. Fall of 46·7 lbs. hammer.	Energy absorbed.	Bending angle.	Hardness Tests. Indentations in 1/100 inch. Load in tons, 1·5.	Load in tons, 2·5.	Brinell ball test Hardness no. Normalised specimens.	Specific Gravities at 17—18°C.	Specific Volume at 17—18°C.	Dilatations Coefficients + 10⁶.	Resistivities Microhm. Cm. at 17°C.	Corrosion Tests. Percentage Loss. After 32 days in water.	After 33 days in sea water.	After 17 days in 30 per cent. sulphuric acid.	
1	2 Per cent.	3 Per cent.	4 Per cent.	5 Bent to	6 Tons per sq. in.	7 Tons per sq. in.	8 Per cent.	9 Per cent.	10 Inch lbs.	11 Degrees.	12 Per cent.	13 Lbs. per sq. inch.	14 Ins.	15 In. lbs.	16 Degrees.	17	18	19	20	21	22	23	24	25	26	27
A.	—	0·47	0·95	180° U	21·00	38·19	25·0	51·23	4,477	—	36·98	32,100,000	13·23	451	18·0	7·2	15·0	202	7·880	0·1269	—	20·3	0·15	0·23	—	A.
B.	1·20	0·48	0·75	180° U	23·93	40·93	21·0	42·80	5,077	405	36·21	30,700,000	13·05	428	17·0	6·4	14·5	207	7·890	0·1267	11·22	22·6	0·11	0·23	1·10	B.
C.	2·15	0·47	0·86	180° U	23·67	41·52	24·5	51·83	5,669	621	37·54	30,500,000	13·67	454	16·5	7·0	19·5	212	7·884	0·1268	11·12	24·8	0·10	0·26	0·72	C.
D.	4·75	0·49	0·82	180° U	29·16	47·66	20·0	33·06	5,071	468	31·13	29,900,000	13·92	460	15·5	6·0	12·3	217	7·867	0·1271	11·36	29·1	0·11	0·26	0·71	D.
E.	4·95	0·42	1·03	30° B	33·95	60·09	2·0	3·71	6,439	177	6·64	29,300,000	13·67	217	0°	4·2	8·7	321	7·876	0·1270	12·07	39·3	0·12	0·24	0·66	E.
F.	6·42	0·52	0·92	10° B	none detected	110·57	nil.	nil.	7,497	42·6	5·73	28,000,000	13·67	105	0°	2·5	5·5	532	7·885	0·1268	12·23	42·8	0·32	0·23	0·58	F.
G.	7·95	0·43	0·79	5°	none detected	77·38	nil.	nil.	7,938	20·1	3·57	27,300,000	14·15	230	0°	2·5	5·7	578	7·883	0·1269	12·13	43·9	0·12	0·23	0·54	G.
H.	12·22	0·41	0·85	10° B	34·56	80·24	1·0	1·63	8,621	31·5	7·52	27,500,000	14·17	436	7·5	3·2	6·2	555	7·904	0·1265	13·28	50·5	0·10	0·23	0·44	H.
J.	15·98	0·45	0·83	60° B	28·53	80·24	5·5	7·33	7,339	118·5	9·31	27,400,000	13·33	432	14·5	5·0	10·3	293	8·026	0·1246	17·54	63·3	0·09	0·18	0·28	J.
K.	19·91	0·41	0·96	180° U	15·33	43·92	55·0	63·11	5,662	60·0	29·94	29,600,000	13·77	452	28·0	16·	40·	131	8·122	0·1231	19·65	75·4	0·09	0·14	0·28	K.

In column 5 U. signifies unbroken, B. broken.

TABLE.

Ni. Alloy.	Content of			Yield point. Tons per sq. in.	Max. Stress. Tons per sq. in.	Elongation on 1·75 in. per cent.	Reduction of area per cent.
	Ni. per cent.	C. per cent.	Mn. per cent.				
A.	—	0·47	0·95	19·24	38·49	15·42	16·26
B.	1·20	0·48	0·79	22·07	43·23	14·28	14·88
C.	2·15	0·47	0·86	25·79	42·84	17·70	23·51
D.	4·25	0·40	0·82	28·11	43·49	13·10	17·94
E.	4·95	0·42	1·03	36·00	56·09	14·28	24·43
F.	6·42	0·52	0·92	37·13	57·51	6·20	8·42
G.	7·95	0·43	0·79	41·47	74·03	4·50	5·68
H.	12·22	0·41	0·85	39·85	71·19	6·20	6·88
J.	15·98	0·45	0·83	31·59	76·55	4·00	4·21
K.	19·91	0·41	0·96	17·94	29·69	14·30	19·05



permeability bridge, and the resulting permeability curves are shown in the appended figure. A series of time temperature curves showing the range of solidification are included, and from these curves the data in the following table has been compiled.

The first two results are included for comparison, a remark also applicable to the last one, that of metallic nickel. In determining critical ranges the differential method of Roberts Austen has been used, and an extensive series of heating and cooling curves are given. These curves show that progressive increments of nickel successively lower the position of the critical ranges, this lowering becoming more accentuated after a content of 4 per cent. nickel has been passed. A consideration of the reversibility of the critical ranges leads to the conclusion that alloys A to D may be classed as approximating to reversible alloys, whilst G and H are irreversible, E and F occupy an intermediate position, their upper limits being

Ni. Alloy.	Percentages.			Beginning of Solidification.	End of Solidification.
	Nickel.	Carbon.	Manganese.		
2	Nil	0·02	Trace	1,504° C	1,470° C
9	Nil	0·47	Trace	1,482° C	1,416° C
A.	Nil	0·47	0·95	1,420° C	1,241° C
B.	1·20	0·48	0·79	1,415° C	1,241° C
C.	2·15	0·44	0·83	1,408° C	1,230° C
D.	4·25	0·40	0·82	1,454° C 1,451° C	1,332° C 1,320° C
E.	4·95	0·42	1·03	1,390° C	1,200° C
F.	6·42	0·52	0·92	1,420° C	1,264° C
G.	7·95	0·43	0·79	1,402° C	1,242° C
H.	12·22	0·41	0·85	1,409° C	1,264° C
J.	15·98	0·45	0·83	1,406° C	1,242° C
K.	19·91	0·41	0·96	1,383° C	1,219° C
Pure Nickel.	99·30	—	—	1,427° C	1,343° C

reversible and their lower ones irreversible. J also shows the same property, whilst K cannot be classed. The metallography of the series is described at considerable length and illustrated by nine plates of photomicrographs.

*Electric Steel Furnaces.**—In a paper read before the Bethlehem meeting of the American Electro Chemical Society Mr. Gustave Gin describes his new process for the production of steel. The accompanying plan shows the construction of the furnace. It comprises a crucible (1) for fusion and refining by oxidation; a compartment (2) for the reduction of oxide of iron and recarburisation; and (3) a final finishing chamber. The electrodes of (1) are connected to one of the terminals from the source of electricity and the electrodes of 2 and 3 are both connected with the other terminal. The current passes from the electrodes to the metal through a layer of slag which is the principal seat of the heating action of the current. The baths of metal communicate by openings B, the channels being of reduced section. When starting, molten pig iron or steel is introduced through A and it distributes itself through the three compartments on the floors of which scrap has been spread. Arcs are then created and further charges introduced in stages. The oxidising slag of (1) may be rendered basic by the addition of lime if the pig iron used is phosphoric. The slags of 2 and 3 are maintained in a neutral condition. By the method of circulation adopted the metal refined in (1) passes into (2) where any dissolved ferrous oxide is reduced and the metal recarburised, the final product being tapped from (3).

Oil Furnaces.†—In this paper by Mr. J. McMally, read before the Railway Master Blacksmiths' Association the subject of oil firing for smith's hearths and furnaces is considered. It is shown that atomising the oil by means of compressed air as far as smith's work is concerned is not a decided success. The method advised is to first burn the oil with a small quantity of air, supplied by a fan, in an independent chamber, thereby breaking it up into hydrocarbons, carbon monoxide, free hydrogen, &c. These gases are supplied with a second and larger volume of air and completely burned in the hearth or furnace. This method gives a perfect combustion of the oil with low operating costs and supplies a soft dry heat to the furnaces.

General Metallurgy.

The Theory and Practice of Roasting.—In a recent issue of the Mining Magazine Mr. A. W. Warwick raises some very pertinent points relative to roasting, and at the same time emphasises the scanty state of the literature on the theoretical and practical aspects of this operation. The chemical reaction which takes place when iron pyrites is roasted, while simply written

$$4\,Fe\,S_2 + 11\,O_2 = 2\,Fe_2O_3 + 8\,SO_2$$

cannot be accepted as more than a partial statement of all the facts. For example, we know that a ton of pyrites cannot be instantaneously flashed into $Fe_2O_3 + SO_2$; time is essential. As time is essential the reaction must have a certain velocity, and it is of some importance to inquire whether this velocity is governed by laws well defined or otherwise. Further, the reaction develops heat, *i.e.* energy, and it would be well to know the amount of energy so produced and whether it can be directed to give a better control over the reaction. Finally, it is desirable to know the stages through which the reaction passes. Mr. Warwick in discussing these matters tentatively develops certain ideas based on a large amount of experimental work. Thus FeS_2 is a definite chemical molecule with one atom of sulphur very strongly held and one atom more weakly linked but not as loosely held as is commonly taught. In an oxidising atmosphere at a temperature of 575° to 600° Fahr. the molecule breaks up, possibly hastened by the flying off of the weakly held atom of sulphur. Heat developed by oxidation raises the temperature to about 850° Fahr. At the period of disintegration and while the whole system is in a state of unstable equilibrium, in an oxidising atmosphere the atoms of iron and sulphur are completely converted into oxides. The molecule FeS is either never formed, or is so transitory, that it may for all practical purposes be assumed never to exist. Evidence is offered to show that this is the case, and the presence of sulphates in the roasted material and sulphuric anhydride in the gases evolved during roasting is explained by the presence of suitable oxides which give the base necessary to form sulphates, provided the temperature is not too high. The complete transformation of pyrites into oxide of iron and sulphurous oxide may therefore possible occur in the following stages:

$$2\,Fe\,S_2 + 3\,O_2 = 2\,Fe\,O + 2\,S\,O_2 \quad (1)$$
$$2\,S\,O_2 + O_2 + \text{catalytic agent} = 2\,S\,O_3 \quad (2)$$
$$S\,O_3 + Fe\,O = Fe\,S\,O_4 \quad (3)$$
$$Fe\,S\,O_4 + Fe\,O = Fe_2O_3 + S\,O_2 \quad (4)$$

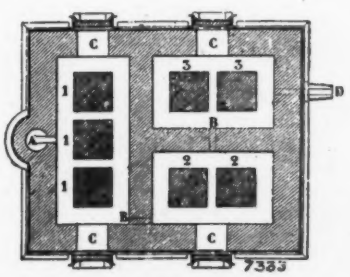


FIG. 1.—GIN STEEL FURNACE.

* *Electro-Chemical Metallurgical Industry*, October 15th.
† *Iron Trade Review*, September 14th.

the final result being

$$4\,Fe\,S_2 + 11\,O_2 = 2\,Fe_2\,O_3 + 8\,S\,O_2 \quad (5)$$

In plain oxidising roasting whilst the presence of magnetic oxide of iron is of itself harmless, yet it is a bad symptom since it usually shows a deficiency of air supply. The formation of this oxide is explained as follows; the ore on being turned over carries some air into the roasting mass which is insufficient to completely oxidise the sulphur, and the sesquioxide of iron is reduced thus:

$$Fe\,S_2 + O_2 + 10\,Fe_2\,O_3 = 7\,Fe_3\,O_4 + 2\,S\,O_2$$

The reaction is probably completed in two stages

$$Fe\,S_2 + O_2 = Fe\,S + S\,O_2 \quad (1)$$
$$Fe\,S + 10\,Fe_2\,O_3 = 7\,Fe_3\,O_4 + S\,O_2 \quad (2)$$

This reaction is interesting in that it typifies a large number of erratic phenomena often observed in roasting. Turning to the velocity of the changes Mr. Warwick presents some data as to the rate of expulsion of sulphur when roasting pyrites in a "Brückner" furnace. The two ores available had the following analysis:—

	1.	2.
S.	15·2	35·06
As.	9·7	1·24
Fe.	22·2	29·40
Si O2	49·8	31·35
Other constituents	3·1	2·95

The results were as follows:—

ORE No. 1.

Time.	Temperature °C.	Per cent. Sulphur.
Commenced to burn	300	15·2
1 hour after	510	13·2
2 hours after	—	10·1
3 ,, ,,	—	7·4

ORE No. 1—*continued.*

Time.	Temperature °O.	Per cent. Sulphur.
4 hours after	610	5·6
8 ,, ,,	675	2·1
18 ,, ,,	750	0·11

ORE No. 2.

Commenced to burn	310	35·06
10 hours after	530	18·50
20 ,, ,,	545	10·00
36 ,, ,,	600	3·20
48 ,, ,,	775	0·60

Finally, roasting is considered in its thermal aspect and various types of roasting furnaces are described.

*Aluminium as a Reducing Agent.**—In order to produce pure titanium and tungsten the author combines the Goldschmidt method with electric arc heating. Inert powders such as fluor spar or cryolite are added to the charge to reduce the velocity of the reaction. The charge is placed in the cavity of a magnesite lined furnace and an arc started just above the charge. Usual heating times were 5 minutes at 300 amps. and 70 volts, followed by 5 minutes at 600 amps. and 80 volts and some fifty reductions were made by this method. The reaction was occasionally vigorous but never explosive, although 350 grams of powdered aluminium were used in some cases. The oxides reduced were those of iron, nickel, cobalt, chromium, manganese, molybdenum, titanium and tungsten. The amount of retarder was diminished in case of the less readily reducible oxides. In a few cases the reaction could have been induced by the usual method of an igniter, but owing to the presence of silica, boric anhydride, or both, most of the charges required the heat supplied by the electric arc to complete the reaction.

* DR. O. P. Watts, American Electro-Chemical Society (*Electro-Chemical and Metallurgical Industry*). October.

In this section is presented every month a list of the principal contents of the leading organs of the technical press and of the proceedings of learned societies throughout Great Britain, the Continent, and America. An alphabetically-arranged list of the publications regularly reviewed, together with the place of publication and price, was given on pages 195—196 of the August issue.

CIVIL ENGINEERING.

Bridges.

The Havre de Grace Bridge of the Pennsylvania Railroad. *Railway Age*, *6th October*, 1905.

Williamsburg Bridge, New York. *Engineering*, *27th October*, and *3rd November*, 1905.

The Plauen Viaduct. *Engineer*, *27th October*, 1905.

Some Through Plate-Girder Bridges, New York, New Haven, and Hartford R. R. *Engineering Record*, *7th October*, 1905.

A Through Truss Short-Span Double-Track Bridge. *Engineering Record*, *21st October*, 1905.

Bridges on the Bow to East Ham Widening; London, Tilbury and Southend Railway, II. *Railway Engineer*, *November*, 1905.

The Concrete Railway Viaduct at Cannington. *Engineering Record*, *21st October*, 1905.

The Ferry Bridge across the Ship Canal at Duluth, Minnesota. *Proceedings American Society Civil Engineers*, *October*, 1905.

Notes on Truss Design I., II. *Mechanical World*, *13th* and *27th October*, 1905.

Assisted Cantilever Method: As applied to the Erection of Permanent Steel-Work for the Western Maryland Railroad Cumberland Extension. *Stevens' Institute Indicator*, *July*, 1905.

Canals, Rivers and Harbours.

New Graving Dock at Southampton. *Engineer*, *20th October*, 1905.

The Inferiority of Canals as a means of Freight Transport. *Engineering News*, *19th October*, 1905.

The Present Status of the Panama Canal. *Engineering Record*, *7th October*, 1905.

A New Graving Dock at Nagaski, Japan. *Proceedings American Society Civil Engineers*, *October*, 1905.

Construction and Maintenance of Docks and Wharves on the Great Lakes. *Railway and Engineering Review*, *21st October*, 1905.

The Accessibility of Ports. *Engineering*, *13th October*, 1905.

Irrigation.

Irrigation Engineering, I, II, III, IV. *Engineer*, *20th*, *27th October*, *3rd*, and *10th November*, 1905.

Miscellaneous.

BUILDING.

Construction and Design.

Reinforced Concrete *v.* Columns. *Railway Engineer*, *November*, 1905.

Reconstruction of the Mercantile Building, New York City. *Engineering Record*, *28th October* 1905.

Coaling Lower Foundations of the Union Electric Light and Power Company, St. Louis. *Engineering Record*, *21st October*, 1905.

Heating and Ventilation.

MEASUREMENTS AND MATERIALS.

Results of Tests of Fire-proof Wood at the Insurance Engineering Experimental Station. *Engineering News*, *5th October*, 1905.

The Manufacture of Concrete Blocks and their Use in Building Construction. *Engineering News*, *5th* and *12th October*, 1905.

The Importance of Preliminary Tests of Paving Materials. *Engineering Record*, *7th October*, 1905.

MECHANICAL ENGINEERING.

Boilers, Furnaces and Fuel.

On the Specific Heat of Gases at High Temperatures. *Physical Review*, *October*, 1905.

The Use of Fuel Oil on the Pacific Coast, II. *American Machinist*, *14th October*, 1905.

Coal Testing. *Journal of Gas Lighting*, *&c.*, *31st October*, 1905.

Engines and Motors.

The Warren Steam Turbine. *Engineer*, *27th October*, 1905.

The Koerting Four-cycle Gas Engine. *Power, October*, 1905.

The Steam Turbine. *Power, October*, 1905.

The Expansion of Wet Steam. *Engineer, 20th October*, 1905.

Ball Side-crank Automatic Engines. *Electrical World and Engineers, 7th October*, 1905.

Four-cycle Gas Engines driven by Blast-furnace Gas. *Engineering, 3rd November*, 1905.

Efficiency in Compression in Steam Engines. *Engineer, 3rd November*, 1905.

The Problem of the Gas Turbine. *Electrician, 10th November*, 1905.

600-H.-P. Horizontal Tandem Compound Engine. *Engineer, 10th November*, 1905.

German Rolling Mill Engines and their Design. *Iron and Coal Trades Review, 3rd November*, 1905.

Method of Computing the Amount of Superheating of Steam in the Cylinder of a Superheated Steam Engine. *Stevens' Institute Indicator, July*, 1905.

Possible Advantages of the Triple Expansion Engine over the Compound. *Engineer, Chicago, 16th October*, 1905.

Marshall's Valve Gear. *Engineer, 3rd November*, 1905.

Condensing Plants for High Vacuums, I. *Machinery, October*, 1905.

New Steam Turbine Power Plant of the Detroit Edison Company. *Engineering Record, 7th October*, 1905.

Power and Transmission.

Hydraulics.

Turbine Pumping Plant of the Buffalo Water Works. *Engineering Record, 28th October*, 1905.

Worthington Turbine Pumps. *Practical Engineer, 3rd November*, 1905.

Pelton Wheel with Adjustable Nozzle for the Glyn Slate Company. *Engineering, 13th October*, 1905.

Compressed Air.

A Central Compressed Air Power Plant for Heavy Railroad Construction. *Engineering Record, 28th October*, 1905.

Shop Equipment and Practice.

Machine Shop Work, I., II. *Mechanical World, 13th* and *27th October*, 1905.

The Cutting Capacity of Power Presses. *American Machinist, 28th October*, 1905.

Machine Tool Design XII. *Engineer, 3rd November*, 1905.

A New Method of Driving Floor Boring Machines. *American Machinist, 14th October*, 1905.

Cutting Spiral Gears. *Machinery, October*, 1905.

Boring Tools. *Machinery, October*, 1905.

Planing Machine for Turbine Construction. *Engineer, 13th October*, 1905.

Miscellaneous.

The Friction of Roller Bearings. *Machinery, October*, 1905.

Designing Beam Rolls. *Mechanical World, 27th October*, 1905.

Belt Coal Conveyors. *Electrician, New York, 1st November*, 1905.

RAILWAY ENGINEERING.

Motive Power and Equipment.

Compound Mogul with Superheater—M., St. P. and S. St. M. Railway. *Railway Master Mechanic, October*, 1905.

Balanced Compound Locomotive, P.R.R. *Railway and Engineering Review, 7th October*, 1905.

Balanced Compound for Pennsylvania Lines. *Railway Age, 13th October*, 1905.

New De Glehn Compound Locomotive for Great Western Railway of England. *Railway and Locomotive Engineering, October*, 1905.

French 6-2-2-6 Compound Freight Locomotive. *Railway and Engineering Review, 7th October*, 1905.

Self-discharging Single-Hopper Waggon—Prussian State Railways. *Engineering, 13th October*, 1905.

New American Valve Gears for Locomotives. *Engineer, 20th October*, 1905.

Gasoline Motor Car No 2 U.P.R.R. *Railway and Engineering Review, 7th October*, 1905.

Heavy Passenger Locomotive for Lackawanna. *Railway Age, 27th October*, 1905.

Compound Locomotives on the Great Western Railway. *Engineering, 3rd November*, 1905.

Prairie Type Engine for the Chicago, Burlington and Quincy. *Railway Gazette, 3rd November*, 1905.

A New Four-wheel Passenger Truck. *Railway Gazette, 13th October*, 1905.

Sixteen-wheel Double Tank Locomotive for the Northern Railway of France. *Railway Gazette, 20th October*, 1905.

A Combination Spring Draft Gear. *Railway Gazette, 10th November*, 1905.

A Storage System for Heating Refrigerator Cars. *Railway Age, 27th October*, 1905.

Permanent Way and Fixtures.

The Travis Rail Loader and Unloader. *Railway Gazette, 3rd November*, 1905.

A Case of Broken Steel Rails on a Bridge. *Engineering News, 26th October*, 1905.

Miscellaneous.

The Grand Trunk Pacific Railway. *Railway Age, 13th October*, 1905.

Tests of Air Brake Apparatus and Friction Draft Gear. *Railway and Engineering Review, 28th October*, 1905.

Tests of 700 lbs. Wheels. *Railway Gazette, 13th October*, 1905.

Explosion of a Locomotive near St. Lazare, Paris. *Le Génie Civil, 21st October*, 1905.

Reinforced Concrete Structure for Railroads. *Engineering Record, 28th October*, 1905.

AUTOMOBILISM AND ROAD TRACTION.

The Albion Mechanical Lubricator. *Autocar, 28th October*, 1905.

The Mitchell Epicyclic Gear. *Autocar, 14th October*, 1905.

Empire Spring Wheel. *Automotor Journal, 14th* and *21st October*, 1905.

Serpollet Steam Waggons. *Engineer, 27th October*, 1905.

Speed Time Curves for Automobile Motors. *Electrical World and Engineer, 21st October*, 1905.

Klee's Tangential Stearing-Gear. *Automotor Journal, 11th November*, 1905.

140 h.-p. Wolseley Petrol Motor. *Engineering, 10th November*, 1905.

Vanadium Steel for Motor Construction. *Autocar, 4th November*, 1905.

ELECTRICAL ENGINEERING.

Electric Lighting.

The Series-Parallel Railway Controller. *Electrical Review, New York, 14th October*, 1905.

Thermodynamics of the Electric Incandescent Lamp. *Electrical Review, New York, 7th October*, 1905.

The Graphitized Filament Incandescent Lamp. *Electrical World and Engineer, 14th October*, 1905.

High Efficiency Incandescent Lamps. *Engineer, Chicago, 16th October*, 1905.

Some Tests on Lamp Globes. *Electrician, 3rd November*, 1905.

The Lighting of Modern Workshops, *L'Elettricita, 27th October*, 1905.

Lighting by Means of the Nernst Lamp. *L'Elettricita, 3rd November*, 1905.

Generation and Transmission.

The Power Station, *Electrical Review, New York, 21st October*, 1905.

The Largest Hydro-electric Installation in Southern Asia. I, II. *Electrical Review, New York, 14th* and *21st October*, 1905.

The Municipal Central Power Station of Hanover, Germany. *Power, October*, 1905.

Electrical Supply in Hartford. *Electrical World and Engineer, 21st October*, 1905.

The Power Plant for the New Wanamaker Store, Philadelphia. *Engineering Record, 28th October*, 1905.

Characteristics of Dynamos. *Engineer, Chicago, 16th October*, 1905.

Alternating Current Generator. *Journal Franklin Institute, October*, 1905.

Dynamo Heating Time Constants. *Electrical World and Engineer, 28th October*, 1905.

Wave Shapes in Three-Phase Transformers. *Electrician, 10th November*, 1905.

A Unique Coal Handling Plant for an Electric Power Station. *Engineering News, 19th October*, 1905.

The Missouri River Powerhouse of the Metropolitan Street Railway Company, Kansas City. Missouri. *Engineering News, 19th October*, 1905.

A Proposed Phase Regulator and its Applications. *Electrical World and Engineer, 21st October*, 1905.

Electric Power on the Blackstone River, Mass. *Electrical World and Engineer, 14th October*, 1905.

Notes on Certain Three-wire Systems. *The Engineer, Chicago, 2nd October*, 1905.

Dynamo Iron Loss Increment on Full Load. *Electrical World and Engineer, 7th October*, 1905.

The Power Station Load Factor as a Factor in the Cost of Operation. *Electrical Review, New York, 14th October*, 1905.

One *v.* Two Dynamos for a Three-Wire System. *Electricity, New York, 1st November*, 1905.

Armature Reaction in Rotary Convertors. *Electrical World and Engineer, 7th October*, 1905.

On the Establishment of Current in Transformers. M. Johann. *Bulletin Soc. Inst. des Electriciens*. Vol. V., No. 48.

Electric Traction

Belfast City Tramways. *Tram and Railway World, October*, 1905

The Single-Phase Railway System. *Railway Age, 20th October*, 1905.

New York Rapid Transit Railway, I, II, III, IV. *Engineer, 13th, 20th*, and *27th October*, and *3rd November*, 1905.

Insulation of Overhead Lines. *Engineering, 13th* and *27th October*, 1905.

The Tramway System of Hastings. *Tram and Railway World, October*, 1905.

European Single-Phase Railways. *Electrical World and Engineer, 21st October*, 1905.

English Electric Railway Practice. *Practical Engineer, 3rd November*, 1905.

An Alternating Direct Current Railway System, *Railway Gazette, 3rd November*, 1905.

Overhead *v.* Underground Lines. *Western Electrician, 14th October*, 1905.

Multiple-unit Systems of Train Control. *Electrical Review, New York, 14th October*, 1905.

The Practical Operation of a Modern Railway Sub-station, I., II. *Western Electrician, 30th September* and *7th October*, 1905.

Niagara Electric Power for Steam Railways of Western New York. *Railway and Engineering Review. 14th October*, 1905.

The Westinghouse Electro-Magnetic Brake. R. Braun. *Elestrikche Bahnen u Betribe, 4th November*, 1905.

Miscellaneous.

Electrical Blast Furnace Hoist. *Engineer, 10th November*, 1905.

The Influence of Electricity on Power Engineering. *Electrician, 13th October*, 1905.

Test of Electric Passenger Elevators in the Park Row Building New York City. *Stevens Institute Indicator, July*, 1905.

The Electric Lift of Burgenstock, Switzerland. *Le Génie Civil, 21st October*, 1905.

Electrical Nature of Matter and Radioactivity, V., VI. *Electrical Review, New York, 7th, 14th*, and *21st October*, 1905.

Location of Small Switches and Fuses. *Electricity, New York, 18th October*, 1905.

The Design of Multiple Coil Windings. *Electrical World and Engineer, 14th October*, 1905.

Relation of Pull to Diameter of Solenoids. *Electrical World and Engineer, 7th October*, 1905.

Remarks on Oscillatory Phenomena in Networks; Influence of the Properties of the Electric Arc. *Bulln. Soc. Int. des Electriciens*, Vol. V. No. 48.

On the Regeneration of Copper Oxide Elements. *Centralbtt. für Accumuln. 1st November*, 1905.

On Linear and Turning Magnetic Hysteresis. *Zeitschft. für Elektrotechnik, 5th November*, 1905.

MARINE ENGINEERING AND NAVAL ARCHITECTURE.

Engines of the Sea-going Motor Launch, *Iris. Engineering, 3rd November*, 1905.

Suggestions as to the Adaptability of a Universal Standard Flange List for Marine Work. *Steamship, November*, 1905.

The Determination of the Principal Dimensions of the Steam Turbine, with Special Reference to Marine Work. *Steamship, November*, 1905.

MUNICIPAL ENGINEERING.

Water Supply.

The Baden Reservoir of the St. Louis Waterworks. *Engineering Record, 21st October*, 1905.

The Sanitary Protection of Water Supplies. *Journal Franklin Institute, October*, 1905.

The Mechanical Filters at Youngstown. *Engineering Record, 7th October*, 1905.

Sewage.

Streets and Pavements.

ENGINEERING ECONOMICS.

MISCELLANEOUS.

The Manufacture of Cartridge Cases for Quick-Firing Guns. *Engineering, 27th October* and *3rd November*, 1905.

The Action of Capped Armour-Piercing Shell. *Engineering News, 5th October*, 1905.

Electrical *v.* Mechanical Speed Control. *Engineer, Chicago, 16th October*, 1905.

Crompton's Direct Reading Pyrometer. *Marine Engineer, November*, 1905.

A Novel Steel Tower and Concrete Platform for Wood Stave Water Tank. *Engineering News, 26th October*, 1905.

The Hatchet Planimeter. *Railway Master Mechanic, October*, 1905.

The Use of Vanadium in Metallurgy. *Engineering, 3rd November*, 1905.

A Graphic Calculator. *Proc. Inst. Mining and Metallurgy, October*, 1905.

Shearing Stresses. *Engineering, 10th November*, 1905.

Notes on Non-Euclidean Geometry. *Ann. de l'Association des Ingens, sorties de Gand*, 1904, III., *4me fasce.*

The Motor Exhibition at Olympia.

THE Fourth International Motor Exhibition, held by the Society of Motor Manufacturers and Traders, was held at Olympia at the end of last month. The exhibition, which embraced all sections of the motor industry, was far larger and more representative than any held before, over one hundred firms showing motor cars, thirty-five showing commercial vehicles, twenty-six motor boats, and a large number showing carriage work, tyres, components, accessories and machinery. A proof of the recognition of the great value of Great Britain as a market was to be found in the fact that a large number of foreign firms exhibited, either directly or through their agents, their 1906 models, in spite of the fact that the Olympia show preceded the Paris Salon.

For the motor boat section structural alterations were carried out involving the addition of 10,000 ft. extra space, provided for by rebuilding the *Annexe*, at an expenditure of some £10,000; thus placing the available floor space for the whole exhibition within 7,000 sq. ft. of that occupied by the Paris show of last year.

The present flourishing condition of the motor industry, which was reflected throughout the exhibition, was referred to in a speech made at the luncheon given at the opening by the Hon. Arthur Stanley, M.P., who stated that, at a very moderate computation, the value of the cars running now in the United Kingdom is not less than £15,000,000; that, in addition, at least as much again is invested in the industry; and that at a moderate estimate orders for at least £2,000,000 worth of cars would be placed in the course of the next twelve months.

What is a still further healthy sign for the industry is the fact that the works in Great Britain are able to cope with about 70 per cent. of the demand, a condition of affairs which gives cause for lively gratification when it is remembered that this industry has grown up within the last ten years.

Of the exhibits themselves it would be outside the scope of this journal, to say nothing of the space required, to refer in detail to the pleasure cars shown, and it will therefore suffice to say that, while the general tendency in design was towards standardisation, nevertheless there were numerous improvements in detail evident to those who examined the cars carefully.

The section devoted to industrial vehicles, to which we shall confine our attention, contained numerous interesting examples of up-to-date manufactures, among which public service vehicles were most in evidence. Delivery vans and light motors were well to the fore, while the heavy vehicle section provided several interesting developments.

JOHN I. THORNYCROFT & CO., LTD., CHISWICK.—Of this company's commercial vehicle exhibit, which comprised a thirty-six seated 1906 type omnibus, a 2-ton petrol lorry delivery van and a 24 h.-p. omnibus chassis, we shall select the two latter for a somewhat detailed description, space forbidding us to deal fully with the remaining components of the stand.

The 24 h.-p. chassis has been specially designed to take an omnibus body, and from the following description it will be seen that the vehicle is eminently suitable for use as a public service conveyance. The frame is of the best channel section rolled steel, the engine and gear box being bolted to a narrow parallel underframe, which is secured to the main frame.

The engine is a four-cylinder enclosed water-cooled motor, having a bore and stroke of 4½ in. by 5 in., developing 24 h.-p. at a normal speed of 900 revolutions a minute.

The induction and exhaust valves, which are all mechanically operated, are placed on opposite sides of the cylinders, and the valves themselves are made interchangeable, thus reducing the number of "spares" it may be desirable to carry. Half-speed cam shafts are arranged on both sides of the crank chamber casing, and are driven from the crankshaft.

A separate shaft, driven from the exhaust valve cam shaft through flexible couplings, operates the water circulating pump and the ignition magneto. Lubrication is provided for automatically and efficiently by fitting an oil pump at the bottom of the crank case, driven by half-speed gearing from the crankshaft.

Ignition is by low-tension magneto, the strikers being fitted above the inlet valves and secured in place by special bayonet socket fittings which ensure gas-tight joints and provide for rapid inspection when necessary. The ignitors are operated through vertical rods from the inlet valve cam shaft, and provision is made for varying the timing of the spark from the steering wheel.

The clutch is of the multiple friction disc type, and is remarkably smooth in coming into action. It is completely encased and runs in oil.

Two brake systems are provided, a pedal operating a pair of compensated band brakes on the countershaft, while the side lever applies compensated internal brakes.

The gear box is made of aluminium and is provided with a large flat top cover to facilitate examination. In the design special attention has been given to reducing the lengths of the gear-wheel shafts, and thus to prevent the springing which is such a fruitful source of

noise and trouble where long gear shafts are employed. Three speeds forward and one reverse are provided for, while on the top gear the drive is direct, no gear wheels being employed for the transmission of power. The gears are machined out of the solid from a special grade of steel and brought to a certain temper.

The drive to the straight spur differential gear is transmitted by means of a propeller shaft and bevels, the drive being finally transmitted to the road wheels through a pair of roller chains.

The second and smaller chassis is somewhat similar to the type described above, and is designed to carry loads from 10—25 cwts. at an average speed of 15 miles per hour. It will be seen therefore, that with suitable bodies, the vehicle can be used as a delivery van, shooting brake, char-a-banc, &c. This exhibit, it may be mentioned, was made specially to the order of the Indian Government Railways.

The frame is of channel section, having a supplementary under-frame supported from and beneath the car frame proper. The engine and gear box are both secured to this under-frame, which is inclined downwards and rearwards in order to reduce the angularity between the engine and the propeller shaft.

The wheels are of the artillery type, with worm and quadrant operated by a hand wheel on an inclined column. All pins and joints in the steering gear rods are protected by leather caps. This simple arrangement retains the lubricant, excludes dust, and prevents any possibility of a pin jolting out.

The engine is a standard 24 h.-p. Thornycroft motor, while the carburettor, clutch and change speed gear are similar to those used on the omnibus chassis described above.

Power is transmitted by means of a propeller shaft from the gear box through bevel wheels to the straight spur differential gear. The differential shaft is mounted above the rear axle, which is of stout tubular steel, the whole forming a strong and girder-like structure.

From the differential shaft to the road wheels, the transmission is by means of straight spur pinions and internal tooth rings.

The total area available for any type of body is about 7 ft. by 4 ft.; the width of the body can be increased if raves are built to clear the road wheels.

MESSRS. T. COULTHARD & CO., LTD., PRESTON.—This firm showed two of their well-known, class "K." steam road waggons, both being repeat orders; one for Messrs. Clegg and Kenyon, carriers, Accrington, and the other for Messrs. Bowley & Sons, Battersea Bridge. As this vehicle was fully described and iilustrated on pages 97–98 of the present volume it will suffice to state a few leading particulars. Its capacity on good macadam and paved roads, and on gradients up to 10 per cent., is five tons, with an additional load of three tons on a trailer. Working singly the waggon can carry six tons. The leading dimensions are: Length, 19 ft. 4 in.; width, 7 ft.; platform area, 91 sq. ft.; tare weight, 4 tons 19 cwt. The boiler is Messrs. Coulthard's patent vertical fire-tube type, working at a pressure of 200 lbs. and hydraulically tested to 400 lbs. The tank capacity is 160 gallons, sufficing for a run of from twelve to fifteen miles. The engine is of compound type, with link reversing gear developing 30 b.h.p. A special valve is provided whereby live steam can be admitted direct to the low pressure cylinder. All the motion is in an oil-tight casing, which encloses also the reduction compensation gear. An important feature is the method of suspending the engine and casing in the frame. The cylinder end of the combined engine and gear casing is secured to the frame by a double knuckle joint, the other end being carried by slide channels of the frame in large overhung bushes. These in turn are carried in spherical bearings, the bushes forming the bearings for the compensating shaft and sleeve. This method of suspension secures alignment of the various shafts, notwithstanding a distortion of the frame owing to load or road effects.

THE WOLSELEY TOOL AND MOTOR CAR COMPANY, LTD., BIRMINGHAM.—The most conspicuous feature of this stand was the 20 h.-p. public service omnibus of the double-deck type with accommodation arranged for thirty-six passengers. It is fitted with a two-cylinder horizontal engine, 6 in. bore by 7 in. stroke, developing 20 h.-p. at 600 revolutions, and is fitted with half-compression cams to ease starting. No governor is provided, the engine being controlled by a hand throttle on the steering column and a foot throttle in connection with the brake pedal. The gears are of the sliding type and give normally four forward speeds of 2½, 5, 8 and 13 miles per hour respectively, and one reverse speed of 5 miles per hour. Several of these vehicles are already in service at various places, having been supplied to, amongst others, The London General Omnibus Company, The London Motor Omnibus Co., the Birmingham Motor Express, the Wolverhampton Corporation, Great Western Railway.

A 12 cwt. light parcels van was also shown, the body being arranged on one of the firm's standard 6 h.-p. chassis, which is amply strong enough for the work. It may be mentioned that this type of car holds a splendid record for various trials and hill climbing competitions, and is a vehicle specially suitable for business houses where prompt delivery to customers is an important consideration.

A 3-ton delivery waggon for heavy goods completed the industrial vehicle exhibit. It is fitted with a 20 h.-p. two-cylinder horizontal engine, the gearing giving four speeds forward and one reverse.

Mention must also be made of a show board on which were displayed examples of front

axles, two and four-throw nickelled chrome steel cranks by Messrs. Vickers Son and Maxim, one of which was bent as a test of quality.

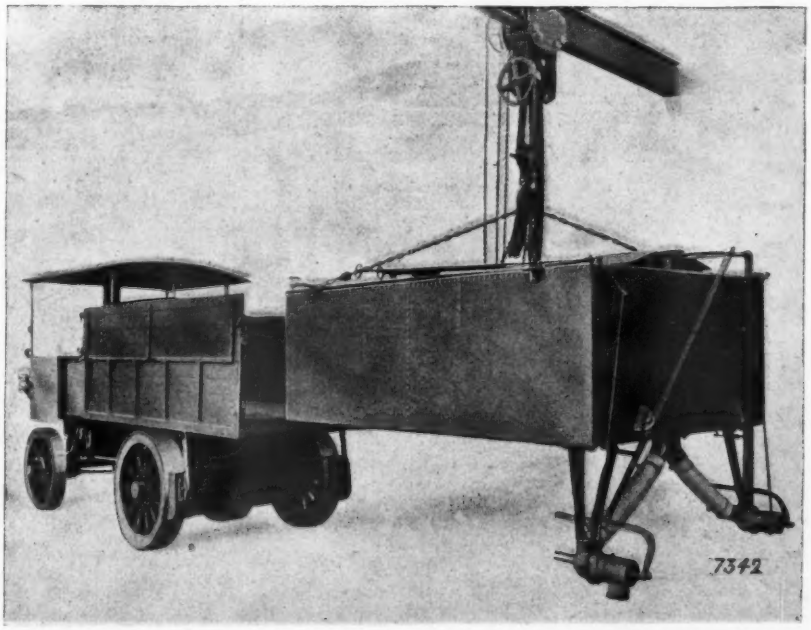
JESSE ELLIS AND CO., LTD., MAIDSTONE.—This exhibit consisted of a 5-ton standard combined steam tipping waggon and street watering van, fitted with a patent sprinkler and flushing head suitable for general municipal purposes.

The method of converting from one to the other is very simple, the whole process not taking more than three minutes. The water tank, which is strongly constructed, is, with the sprinkler, levers, valves, &c., self-contained, so that no delay arises through disconnecting various parts before the tank can be removed. Four tie bolts hold it to the body, and all that is required is to remove these and slide the tank with its attachments out. The body is tipped by either hand or steam power.

The boiler is of the locomotive type, with a large heating surface, the engine being of the horizontal compound long-stroke type, enclosed in a dust-proof and oil-tight casing. The reversing motion is of the ordinary type, and high-pressure steam can be admitted to both cylinders by a by-pass valve. The crankshaft is of mild steel 2¼ in. diameter, with the throws at right angles, fitted with a fly wheel which projects on the outside of the frame and forms a ready means of turning the engine by hand should occasion arise. A helical pinion is keyed to the crankshaft, but the engine is simply and easily thrown out of gear by sliding the fast and slow wheel pinion on the second motion shaft. Keyed on the countershaft is the helical wheel which meshes with the helical pinion on the countershaft, also the fast and slow wheel pinion which slides on the square shaft. The pump also works on the end of the countershaft, and as the latter is always in motion a by-pass and check valve combined is fixed on the boiler so that surplus water can be returned to the tank.

The back axle is of mild steel 3½ in. diameter. On the axle are two steel flanged sleeves, the flanges bolting on the boss of the driving wheels. Power is transmitted through the countershaft to the compound wheel and differential gear, the bevel wheels belonging to which are keyed on the end of each sleeve. The differential gear is all of steel, and strongly proportioned to stand rough usage.

The locking of the compensating gear is by means of a slotted locking collar, which is fixed to the axle by means of a lince pin. A steel slotted locking cap is studded to the boss of the driving



COMBINED TIPPING WAGGON AND STREET WATERING VAN: MESSRS. JESSE ELLIS & CO., LTD.

wheel, a square pin fastened in position by a thumb nut drops in the slot in the locking cap and engages a slot in the locking collar, thus making the same fast.

The trials and results obtained from the vehicle prove it to be a most useful adjunct to any municipality, and, as an auxiliary to horse-work, will be found very economical.

THE HAY MOTOR CO., LTD., PRESTON.—The exhibit of this company, consisting of a six-ton steam lorry, forms a unique feature in the industrial vehicle section, the design comprising several novel features. In developing this vehicle Mr. Hay has been actuated by a desire to place on the market a cheap, simple, and efficient design which could satisfactorily compete with horse traction. An examination of the accompanying illustrations will serve to show how far Mr. Hay has succeeded in achieving simplicity, and when it is stated that the selling price of the vehicle is only £425 it may be taken that the first desideratum has been obtained. As for efficiency, we are informed that an extensive series of trials conducted at Liverpool have proved that the vehicle can be run at the same cost per day as a team waggon, with, however, an increased carrying capacity ranging from 25 to 100 per cent. according to the nature of the work. The engine is of the single-cylinder, low-speed, double-acting type, and has a diameter of 10 in. with a 12 in. stroke. It is fitted with a variable cut-off, and runs normally at 80 revolutions per minute, this giving a speed of five miles per hour.

The effort is transmitted from the crosshead by two connecting rods, an upper and a lower one, which, however, instead of being attached to cranks, reciprocate between two ratchet wheels. The latter are mounted on a solid axle, marked 2 in the illustrations, which extends between the road wheels. These wheels, however, can revolve independently of each other, as they are mounted loosely on this axle.

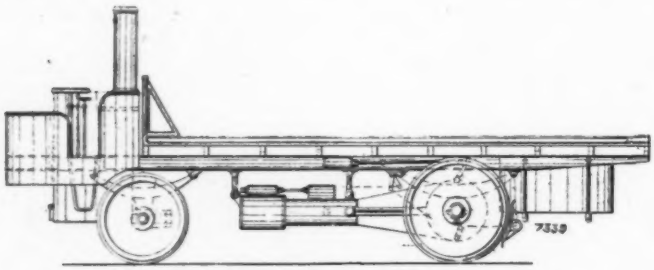
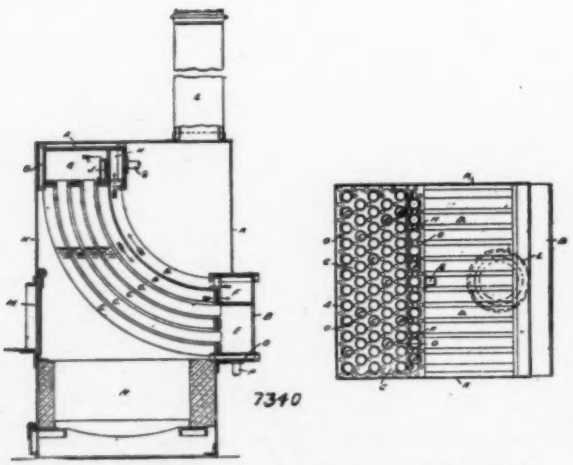


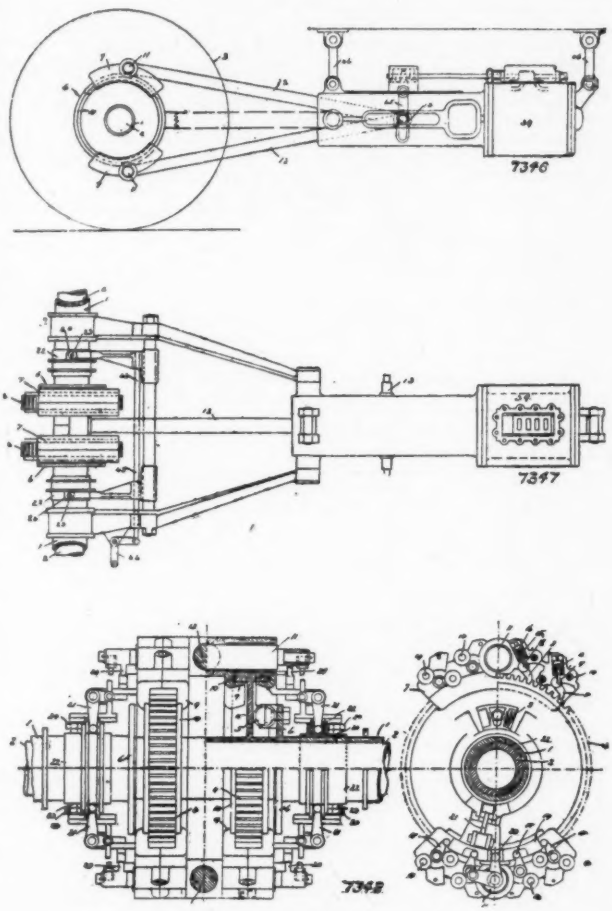
FIG. 1.—THE "HAY" STEAM LORRY: SIDE ELEVATION.



FIGS. 2 AND 3.—THE "HAY" STEAM VEHICLE: DETAILS OF THE BOILER.

The driving shaft is in two portions (1) and forms sleeves round the solid axle (2). Motion is imparted to them, and therefore to the road wheels, through the sleeves (6) by a system of springs (5), which take up and transmit the motion of the ratchet wheels. The latter are revolved by a system of pawls (8) mounted in castings fixed at the ends of the connecting rods, one operating at the top and the other at the bottom of each of the ratchet wheels. On the forward stroke the pawls connected with the upper rod engage with and pull the ratchet wheels forward, the pawls underneath fulfilling a similar duty on the backward stroke. This arrangement is in reality an old friend in a new guise, a similar system being adopted in connection with the "Otto-Langen" engine. For reversing, reverse pawls are brought into action, those connected with the upper rod pushing backwards and *vice versâ*. It will readily be seen that differential gear is dispensed with by reason of the independence of each road wheel; the corresponding independence of

the ratchet wheels being secured by the fact that they can slip past the pawls when one is travelling faster than the other—as, for example, when rounding a curve. Another advantage attaching to the design is that no dead centres are involved. The wheels are of entirely new construction, the notable feature of which consists in the tread, which is fitted with renewable wooden blocks to prevent slipping. Although not fitted to the vehicle exhibited, the boiler to be adopted eventually as standard practice is shown in Figs. 2 and 3. It is of the water-tube type and supplies superheated steam, the tubes *D D* constituting the superheater. The steering is on the "Ackerman" system, with the steering centre inside the wheels. The overall length of the vehicle is 23 ft. 6 in.; the wheelbase 11 ft. 6 in. and the platform area 132 sq. ft. The water tank capacity is 200 gallons, sufficing for a run of twenty to twenty-five miles; the bunker capacity being equal to double that distance.



FIGS 4, 5, AND 6.—THE "HAY" STEAM LORRY: DETAILS OF DRIVE.

FODENS, LTD., SANDBACH. — This company showed one of their well-known 5-ton standard steam waggons, the features of which are so well known that it will suffice to state here that a locomotive type boiler is adopted, the engine being of the compound type, with steam jacketed cylinders placed on top of the boiler. The driving is done by steel cut gearing from the crank shaft to phosphor bronze gearing on a fixed stud shaft, thence by chain to the main axle. Two speeds are arranged, viz., three and six miles per hour. The water tank has a capacity of 170 gallons, sufficient to take a full load fifteen to twenty miles. The fuel bunker will hold sufficient for a forty-mile run. The travelling wheels are extra large, the leading pair being 2 ft. 9 in. by 6 in. on face, and the back pair 3 ft. 6 in. diameter by 10 in.

THE BRITISH AUTOMOBILE DEVELOPMENT CO., LTD., BELVEDERE ROAD, S.E. — A well-finished, handsome 30-h.-p. double-deck omnibus formed the exhibit of this firm, a company formed, it may be mentioned, by the British Electric Traction Co., Ltd., in conjunction with the Brush Electrical Engineering Co., Ltd., and whose first-class and up-to-date works at Loughborough are now complete. The engine with which the vehicle is fitted is of the four-cylinder vertical type, with cylinders of 5 in. bore and 6 in. stroke, with a normal speed of 800 revolutions per minute. All the valves are placed immediately above the pistons, and are mechanically operated. Accumulator ignition is fitted in this particular vehicle, although magneto can be

added independently when desired. The gearing gives three speeds of 4, 8½, and 12 miles per hour, and a reverse, but on the top speed the drive is direct from the engine to the back axle. A specially strong live axle is fitted, carried in horn plates, which are fixed and stayed to the main frame.

The seating capacity of the vehicle is thirty-eight, of which sixteen are inside and eighteen outside. Special attention has been bestowed on the body, which is of non-inflammable wood, of which the company make a speciality. The control has been carefully thought out, the lever arrangements being extremely simple and free from delicate ratchet work.

WALLIS AND STEVENS, LTD., BASINGSTOKE.—On this stand was displayed a compound steam tractor. The engine, which is attached at the top of the locomotive type boiler, is totally enclosed, the motion working in an oil bath. Two speeds are fitted, the drive from the differential to the road wheels being by gear. In other features traction engine practice has been followed, rendering the machine substantial in construction, and particularly adapted for Colonial requirements. The machine is capable of hauling loads up to six tons on average roads. A particular feature of interest exists in connection with the trailer which is supplied with the tractor, it being fitted with a patent backing gear, by means of which the trailer can be pushed backwards, round corners, or into any position required for loading or unloading, without uncoupling.

STRAKER AND MacCONNELL, LTD., 20, AVONMORE ROAD, KENSINGTON.—One of the most interesting features of this stand consisted of a 36-40 h.-p. omnibus chassis fitted with a four-cylinder engine of 120 mm. bore and 140 mm. stroke. The valves are mechanically operated, and the carburettor is of special construction. The water circulation is by a direct-driven "Palette" type of pump, from a tubular type of radiator. The transmission is through a leather-to-metal clutch to the gears, the latter giving four forward speeds and one reverse, all controlled by a single lever. From the gear box the transmission is by a cardan jointed shaft to the live axle, whence the drive is conveyed through pinions acting on internal toothed rings bolted on to road wheels which run free on the main axle. External band brakes act on the road wheels, and a pedal operated internal expansion brake in front of the live axle.

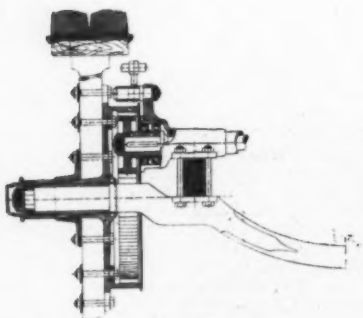
A 24 h.-p. two-cylinder chassis similar to the above was also shown fitted with a double-deck body. The engine of this vehicle consists of two cylinders each of 150 mm. bore and 180 mm. stroke.

A 14-16 h.-p. motor cab also formed a feature of the exhibit.

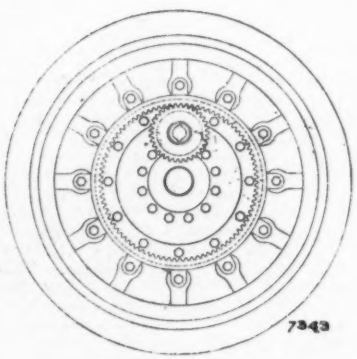
COVENTRY CHAIN CO., LTD., COVENTRY.—The exhibits of this firm were confined to chains and chain wheels, a variety of the former up to 2½ in. pitch, and having a breaking strain of 63,000 lbs., being on exhibition.

The claim made in connection with these chains is that they contain less component parts than other makes of the same size and weight, this being arrived at by making the bushes and side plates from the solid in one part.

ALFRED HERBERT, LTD., COVENTRY.—This company showed a fine selection of machine tools, all of a special type to suit the requirements of the motor car business. The No. 16 combination turret lathe with patent chasing saddle is used in the motor car business for finishing single and double cylinders, gear blanks, front and back wheel naves, fly wheels, friction clutches, &c., and is an exceedingly



Section of Drive.



Inside View of Back Wheel, showing Driving Pinion and Ring.

36-40 H.P. OMNIBUS CHASSIS: MESSRS. STRAKER AND MACCONNELL, LTD.

powerful and rigid machine. Its great strength enables it to swing heavy sliding fixtures for handling double cylinders and similar work, and also to remove a large amount of metal at high speed, as in the case of fly wheels and gear blanks. The height of centres is 11 in., and the headstock is fitted with a large cone for wide belt and has two ratios of double gears operated by friction clutches. These, in conjunction with the two-speed countershaft, enable any one of six spindle speeds to be instantly obtained without stopping the machines.

The main turret is hexagonal in form, and has an automatic feed controlled by six self-selecting automatic trips and dead stops, one to each face of the turret. The supplementary turret is carried on a saddle, which has automatic sliding and surfacing feeds, each controlled by four automatic trips and dead stops, one to each tool. The saddle is also fitted with Messrs. Herbert's well-known chasing arrangement, by which the guide nut and chasing tool are moved in and out together, enabling screw cutting, external or internal, to be done with great rapidity.

The very wide range of feeds and speeds provided enables the machine to deal effectively with articles varying considerably in their nature, such as, cast-iron fly-wheels, and steel bevel gears made from blanks cut from the bar.

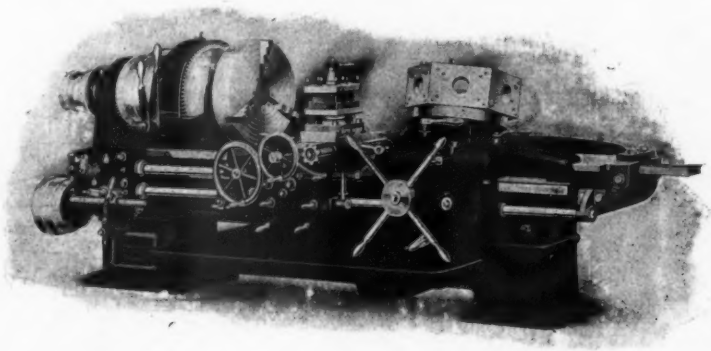
A No. 2 patent hexagon turret lathe was shown in operation. This machine is a new development of Messrs. Herbert's well-known hexagon turret lathes, which are specially valuable for making cam shafts, reversing gear shafts, long bolts, spindles, and such work, from the bar. The principal feature of these machines is the fact that they are suitable for making long or short work, in either large or small quantities, at each setting.

The patent "Single Pulley" headstock entirely dispenses with a countershaft and may be driven, either direct from the line shaft, or from a motor placed on the floor. Sixteen spindle speeds are provided, in four ranges of four speeds each; any one of the four speeds in a range may be instantly obtained by means of friction clutches. The change from one range to another is made by operating the two small handles at the top of the headstock. The tool is moved in and out for various diameters by means of a circular rack, having a screwed shank. The stop screw, which is used for reproducing sizes, passes through the centre of this neck and, therefore, sets up no cross-wind or tilting action on the slide itself, the result being a very sensitive stop: diameters may be reproduced with extreme accuracy.

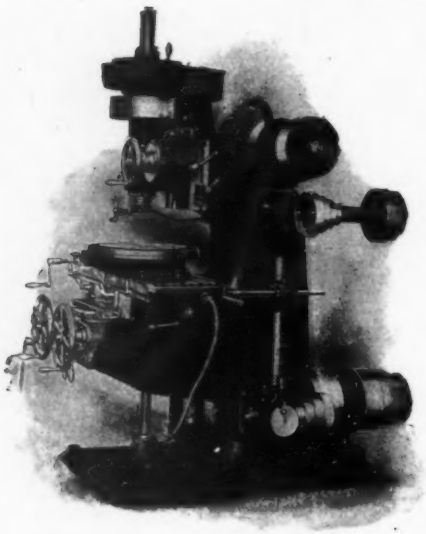
For short and medium work the turret feeds towards the headstock, but, in turning long work, such as car shafts, spindles, &c., a left hand cutter is mounted in the turning tool holder and the feed is reversed, the turret travelling away from the headstock and keeping the job in tension.

It is on this long and slender work that the machine effects very great economies, such pieces being costly to make in the ordinary lathe, as a number of cuts must be taken owing to the work springing away from the tools.

Another useful machine shown was a No. 3 vertical mill, largely used by motor car builders for facing up aluminium gear casings and also for a large amount of general surfacing and edge milling. The spindle, which is of unusually large diameter, is driven through spur gears, or by belt alone, no bevel gears being used. This gives a smooth and steady drive at all speeds. The table is made very deep to withstand distortion and oiled from the front and not from the top, thus enabling it to be lubricated without removing the work or fixture that may be in position. The circular table can be easily removed, leaving the main table free to receive large articles or a number



COMBINATION TURRET LATHE, WITH PATENT CHASING SADDLE: MESSRS. ALFRED HERBERT, LTD.



VERTICAL MILLING MACHINE: MESSRS. ALFRED HERBERT, LTD.

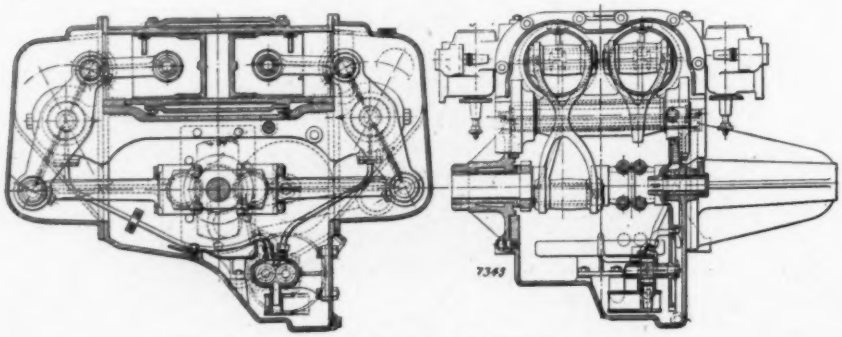
of smallar pieces. The knee is of box form, completely closed in underneath and has the bearing on the column extended above the horizontal surface, thus gripping the column in the most advantageous position. The automatic longitudinal cross and circular feeds are controlled by automatic trips and dead stops, and may be instantly reversed.

The exhibit also included a No. 6 horizontal milling machine, the smallest of a series recently put on the market, and which possess a number of valuable features. Space will not permit us to refer to these beyond stating that the feed is driven through a new form of feed motion of great simplicity. There are nine changes of feed stamped round the edge of a dial, and to obtain any one of these, it is only necessary to rotate the dial until the feed required is opposite a pointer.

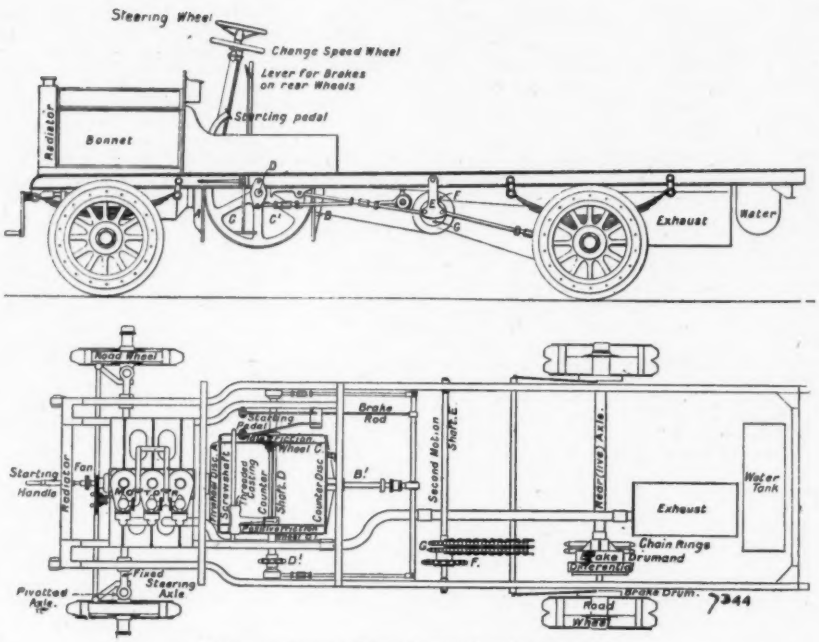
THE NEW ARROL-JOHNSTON CAR CO., LTD., PAISLEY.—On the stand of this well-known company were to be seen a 24–30 h.-p. double-deck motor omnibus to carry 36 passengers, and a 12–15 h.-p. van to carry loads up to 30 cwts.

The omnibus is fitted with a new type of engine in which the four-cylinder vertical arrangement has been adopted. The water-jacket and combustion chamber are separate from the cylinder proper, the former consisting of a corrugated solid-drawn copper tube. The ignition to each cylinder is adjustable, thus permitting the explosions to act independently. All the engine working parts are lubricated by a force-feed system which has been adopted in preference to the splash or to the sight-feed methods. The gear wheels operating the cam-shaft, water-pump and magneto are all enclosed in oil-tight cases, a fibre wheel being interposed between each metal pair to ensure silence. A special type of carburettor is employed which acts in addition as a governor and can be set to control speeds from 200–1200 revolutions per minute.

The speed gear arrangement gives four forward speeds and one reverse. the transmission to this point being through a "Hele-Shaw" clutch. From the gear box to the countershaft power is transmitted by a universal jointed propeller shaft, the drive from the differential to the rear road wheels being by chains, which latter are enclosed in substantial castings. Two systems of brakes are fitted, one acting on the countershaft axles and the other on large diameter drums fitted to the rear road wheels. Connecting the rear axle and the frames are two tubular members on which is clipped the countershaft casing. The wheels are of artillery pattern



DETAILS OF 12-15 H.-P. ENGINE: NEW ARROL-JOHNSTON CAR CO., LTD.



DETAILS OF FRICTION DRIVE: DOUGILL'S ENGINEERING, LTD.

of very substantial construction, solid tyres of 820 × 100 × 75 mm. section being fitted to the front pair, and twin solids of 1000 × 100 × 75 mm. section to the rear pair.

The 12–15 h.-p. van is fitted with an engine similar to that employed on the Arrol-Johnston car which achieved so much success in the tourist trophy race in the Isle of Man some three months ago. In this type of engine, which has been that employed by the company for some years past—modified, however, recently—two pistons are fitted in each cylinder as shown in the accompanying illustration. Each piston is connected to a rocking lever which is in turn coupled to the crank pins. The crank shaft is placed under the cylinders and at right angles to their length. The fly-wheel which is carried on this shaft, is also utilised to serve the purpose of a ventilating fan. The drive on this vehicle is by a chain to the first shaft of the gear box, a second chain transmitting the power to a differential gear mounted on the countershaft. Thence the transmission is by chain to the rear road wheels. The steering is by a poppet arrangement connected by links with a bell-crank lever, the poppet sliding up and down a guide as the hand wheel is rotated. The long end of the bell-crank lever is connected by means of a swivel joint to the steering arm. Internally expanding metal-to-metal brakes are fitted to the hubs of the rear road wheels, a pedal brake being applied to the secondary shaft of the gear box. The wheels, which are of artillery type of substantial construction, are fitted with single solid tyres on the front pair and twin tyres on the rear pair.

DOUGILL'S ENGINEERING, LTD., LEEDS.—One of the conspicuous novelties of the exhibition was the friction system of speed transmission that has been developed by this firm. The details will be readily followed by reference to the accompanying illustrations:—

A fly-wheel friction disc *A* is attached to and practically forms an integral part of the fly-wheel, which is keyed to the end of the crank-shaft. At the rear of the friction wheel *C* is another friction disc *B*, not so heavy as the disc *A*. The counter-disc *B* is keyed to a short longitudinal shaft B_1. Midway between the fly-wheel and friction discs is the countershaft *D*, which carries the two friction wheels. The latter each have peripheries of leather about two inches in width. When the wheel C_1 revolves it has a positive driving effect on the countershaft, upon which it slides on a feather. The wheel *C* runs loose in ball bearings on the countershaft, and has merely a negative position, being used only to increase the area of friction and not to drive the

countershaft. The actual driving wheels of the system therefore are the disc *A*, which acts as the spur-wheel in a gear box would, and the wheel C_1, which acts as a change-speed pinion as well as spur pinion to transmit power from the engine to the countershaft.

A sprocket wheel D_1 is fitted to the countershaft *D*, and carries a chain to a sprocket. Another sprocket *G*, on this shaft transmits the motion by chain to a chain ring and differential gear on the rear axle, which runs live with fixed road wheels.

The operation of the friction drive is extremely simple yet efficient. When the brake lever is released the starting pedal is also freed, and the counter-disc *B* is brought into closer contact with the peripheries of the friction wheels *C* and C_1, which in turn are pressed nearer the fly-wheel disc *A*. As soon as the pressure is sufficient to prevent slipping the wheel C_1 begins to revolve, and drives the countershaft *D* and its sprocket wheel. The countershaft is fitted with swinging bearings to permit its being slightly advanced to or withdrawn from the disc *A* with the wheels *C* and C_1. It is the power of sliding the wheel C_1 on the countershaft and across the face of the fly-wheel disc *A* which permits of changes of speed and reversing. The latter operation is effected by a change speed wheel placed beneath the steering wheel. With the friction drive it is possible to obtain any gradation of speed from minimum to maximum. This is impossible with toothed gear systems, which give only just those speeds for which the speed pinions are pitched.

DE DION BOUTON, LTD., 10, GREAT MARLBOROUGH STREET, W.—Conspicuous on this stand was a 20-seated char-à-banc, but the firm also staged examples of their manufactures as applied to the more commercial vehicles, viz., the delivery van and lorry.

The delivery van is fitted with an 8 h.-p. single-cylinder engine, lubricated by splash. In the system of lubrication for two and four-cylinder engines the oil is circulated by a self-contained pump, the oil being used over and over again and at each circuit drawn through a filter. An overflow pipe prevents excess of oil, so that the nuisance of visible and odorous exhaust is prevented.

The contact breakers used are of the same system on all engines, the one and four-cylinder engines having only one contact screw, whilst the two-cylinder has two. The single-cylinder engine is run a dry battery, but the two and four-cylinder motors are now supplied with gear driven magnetos as well as batteries, the latter being retained to facilitate starting. The current of each system is passed through the same induction coil and plugs.

The carburettors are the well-known De Dion Bouton model with annular float, the spray being placed in the centre so that constant level is maintained irrespective of the inclination of the vehicle. Single sprays are used in the one and four-cylinder motors, but for the two-cylinders, in order to equalise the quality of the gas, two sprays and separate air channels are provided.

The water circulation is maintained by a large centrifugal pump driven through a coil spring. All the models shown are fitted with a metal-to-metal plate clutch, pedal operated, in combination with a sliding pinion gear, the feature of which is the automatic oil circulating pump, similar to that used in the engine.

The transmission from the engine to the gear is by a universally jointed shaft, thence to the road wheels by cardan axles. A very strong continuous hollow back axle with long bearings is provided on which the road wheels run. A jointed axle, carrying no weight, transmits the power from the differential through the hollow axle to the road wheels.

In the De Dion Bouton system of control there are two throttles, one on the carburettor and the other on the exhaust.

Other details of the individual vehicles are as follows:—

The delivery van has an 8 h.-p. De Dion Bouton engine, single cylinder with 106 mm. bore and 120 mm. stroke. Three forward speeds are given, viz., 7, 14 and 21 miles per hour, and a reverse, all actuated by a side lever.

The lorry has a two-cylinder 12 h.-p. De Dion Bouton engine, of 100 mm. bore and 120 mm. stroke. The tare is 1¾ tons, whilst its load is 1¼ tons. Its overall length is 12 ft. 6 in., width 5 ft. 9 in., and the platform measures 48 square feet. The sliding pinion gear gives three forward speeds: 10, 6½ and 3½ miles per hour and reverse. The wheels are 32 and 36 in. dia., wheelbase 8¼ ft., and the track is 4 ft. 8 in. A reducing gear is fitted in which the outer ends of the cardan shaft engage with internally toothed wheels fixed on the hubs, making a less rigid connection between gear and road wheels. The accessibility of all parts is particularly good; for instance, the bottom portion of the crank chamber can be readily detached for the inspection of crank shaft, &c. The workmanlike design and sturdy appearance of this lorry impressed one most favourably.

The char-à-banc is fitted with the same engine as is used on the De Dion Bouton 'buses running in London. It is a four-cylinder 24–30 h.-p. The engine and general details are on the same principle as the other vehicles, but of course the strength is greatly increased. In common with the lorry a reducing gear is fitted to the back hub; the driving axle being fitted with a pinion in engagement with an internally toothed ring fixed on the back hub.

The "Rock" Speed Recorder for Automobiles.

THE accompanying illustrations refer to a new form of speed indicator and recorder designed on lines differing entirely from any other form at present on the market, and which, therefore, possesses several interesting features.

An important advantage is secured by the fact that the component parts do not revolve at high velocities, thus reducing wear and tear, and consequent liability to derangement. Further, the action is positive right through, and does not depend in any way on centrifugal force.

The essential features of the mechanism and the method of action will be readily followed by the aid of Fig. 2, which is a diagram of the interior of the speed indicator dial.

B is a plate pivoted on a pin B^1, and carries, amongst other parts, the two toothed wheels D and E, which may, by the swinging of the plate B on its pin, be brought into mesh with the toothed wheel C. The latter is driven in one direction by the car at a speed proportionate to the velocity of the car.

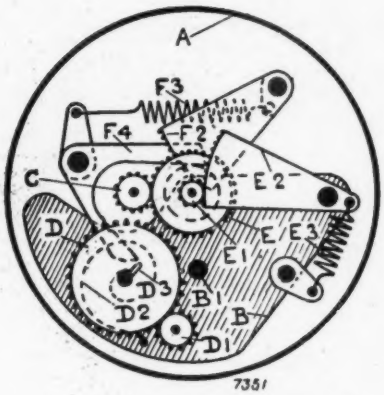


FIG. 2.—DIAGRAM OF THE INTERIOR: "ROCK" SPEED INDICATOR DIAL.

FIG. 1.—THE "ROCK" SPEED RECORDER.

When C is driving the wheel D the motion of the latter winds up a clock-spring D^2. The wheel D, however, only makes half a revolution, as the pin D^3 then causes the frame to rock over, throwing D out of mesh with C, and the wheel E into mesh with C.

As soon as this happens the spring D^2 causes the wheel D to return to its original position, which it does through suitable regulating mechanism, not shown, in exactly two seconds. The pin D^3 then causes the plate B to resume its original position. During this period—*i.e.* two seconds—the wheel E has been in mesh with C, but in that time, no matter at what speed the car be travelling, it cannot make a complete revolution. The wheel E drives the pointer on the free-wheel principle, so that, although E can return to zero position, the pointer is left in the position to which it was moved by E. After the latter has run through two seconds it is caused to return to zero by means of the toothed quadrant E^2, which is pivoted to the plate B.

The brake lever F^4 prevents the return of the pointer to zero, which it would otherwise be caused to do by the spring F^3 and the quadrant F^2. When the wheel E is once more at the end of its two seconds' run the brake F^4 is released by the action of another pin projecting from D, thus allowing the pointer to take up some lower position on the scale corresponding with the

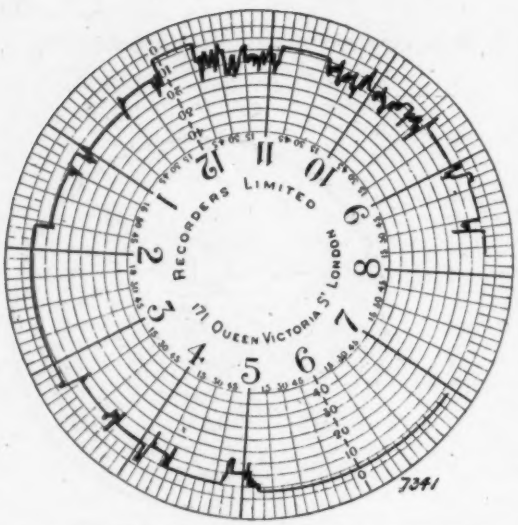


FIG. 3.—CARD RECORD TAKEN ON A "ROCK" SPEED INDICATOR.

speed of the car. Should, however, the speed have increased, the wheel E would have caught up the pointer, which would be rotated to a higher position. The indicator therefore shows the rate of speed intermittently, the periods varying with the speed, so that if the car is pulled up suddenly, the indicator hand shows the last reading. The motion of the car is transmitted to shaft, which drives the indicator by a worm and worm-wheel, such drive naturally varying considerably according to the construction of the particular vehicle. An exterior view of the apparatus is shown at Fig. 1, from which it will be seen that a clock is fixed at the base. By a simple extension from the mechanism of the indicator a record on a card is produced, as shown in Fig. 3.

The radial lines and figures on the record card indicate the time of day, and the circles the various rates of speed in miles per hour. The vertical markings of the recorder show the varying speeds attained by the motor and the concentric markings the stoppages.

The space occupied in the instrument is small, the length being 10 in. and the width 4½ in. It is fixed on the dashboard of the vehicle, so that the driver can readily see the speed at any instant, and the distance travelled as shown by the mileage counter on the top of the indicator.

Tramcar and Electric Railway Trucks.—Time was when American car trucks and under-carriages practically held the field in the tramway equipment of this country. Recently, however, certain British firms have been devoting special attention to this class of work, with the result that practically any requirement can now be met, and the home manufactured article is rapidly gaining the preference. Among the firms mentioned above is that of Messrs. Mountain and Gibson, Ltd., Bury, whose works, which are specially laid out for the manufacture of electric car truck equipment, have recently been considerably extended. The following particulars of two special types of truck made by this company should prove of interest.

"*M. G.*" *21 E. M. Single Truck.*—This is a four-wheel electric tramway motor truck built for gauges up to 4 ft. 8 in., with a wheel base of from 5 ft. 6 in. to 6 ft. 6 in. The car body is supported on eight spiral springs and four three-quarter elliptic springs, all carried upon the side frames; the spiral springs have bases of enlarged diameter to give as great a bearing as possible, and three-quarter elliptic springs are placed at the ends of the side-frames. These have an extended limb carried to the level of the other springs, thus lengthening the spring base of the truck and giving support to the ends of the car body, an arrangement which reduces car oscillation to a minimum. Draft plates are fitted to overcome end thrust.

"*L. C.*" *type adjustable Traction Truck.*—This is for bogie cars, and is of the side bearing pattern. It is constructed with steel-tyred driving wheels of standard size, and is pivoted to the car body practically over the centre of the driving axle. The trailer wheels are of smaller diameter. To prevent derailment on curves from 30 to 50 per cent. of the weight of the car and the load is transmitted to the small or trailer wheels by means of a very simple device, consisting of a coil spring enclosed and located nearly over the small wheels; the anti-friction roller is mounted upon the springs, and a compression plate attached to the car body directly over this roller. This compression plate is made in the form of an inclined plane. The weight is relieved as soon as the truck assumes its normal straight position. A special arrangement is fitted to the driving axle-boxes, the cushion springs being fitted underneath, and these, together with the axle-boxes, are fitted to the swinging links, the thrust or keep plates being fitted to the bottom of the journal boxes. This arrangement relieves the truck frame from jolt and jar. Two hundred of these are in use upon the London County Council tramway system.